Research on the construction of computer science and technology majors in higher education continuing education

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Abstract. The development of computer science and technology is changing rapidly, and those who are engaged in computer science and technology must constantly reinvent themselves and continue to learn and absorb knowledge in order to stand firm in the Internet era and achieve long-term development. In order to provide students with theoretical skills and cultivate truly useful computer application talents for society, continuing education in computer science and technology must meet the needs of society and the times, and explore more appropriate professional construction solutions. China University of Geosciences (Wuhan) has conducted research on the needs of society and then analyzed the competency requirements of computer science and technology majors, and sorted out a list of applied job knowledge, which provides a reference for the construction of professional courses. At the same time, by exploring the project-driven teaching mode, analyzing the professional job competencies and the knowledge points of engineering projects, and selecting suitable engineering projects for inclusion in the professional development programme, the aim is to realize that students can basically develop the required professional job competencies through multiple projects.

Keywords: Further Tertiary Education; Computer Science and Technology; Professional Development

1 Introduction

In recent years, the development of computers is changing rapidly, with cloud computing, big data, artificial intelligence, mobile Internet and other computer development fields showing a hundred flowers. At present, the computer industry is changing the way people live and work, and creating a broad prospect for development. "The 14th Five-Year Plan for the development of the digital economy points out that the construction of information network infrastructure should be accelerated, the development of cloud-network synergy and integration of computing networks should be promoted, and the intelligent upgrading of infrastructure should be advanced in an

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orderly manner [1]. Under the guidance of social demand and national policies, there will be a large number of computer-related jobs released in the market, and the demand for applied talents in computer science and technology will continue to expand.

In order to better respond to the needs of society and cultivate computer application-oriented talents suitable for social development, it is necessary to attach importance to continuing education for higher education in computing. Continuing education can help computer practitioners acquire the latest knowledge and skills, so that they can be more competitive and capable of responding to the development of the industry and the call of the times. This will enable them to better contribute to enterprises and society.

In January this year, the General Office of the Ministry of Education issued a notice on the setting and management of higher academic continuing education majors in 2023, which pointed out that all kinds of school sponsoring bodies should organize in-depth research, analyze the needs of industry enterprises and learners for professional talents cultivation, design the linkage between the setting of majors and enrollment and employment, fully consider the layout of existing disciplines and majors in schools, the number of enrolled students, the market demand of majors and employment competitiveness, highlighting the vocational, application and developmental aspects of talent cultivation[2]. Therefore, in order to make continuing education for higher education in computing fit the needs of personal development, social needs and the needs of the times, it is necessary for researchers of continuing education for higher education in computing to conduct research on the current development of the computing industry, and on this basis, to study the construction of majors for continuing education for higher education in computing and to explore suitable plans for the construction of majors.

2 Research Background

Zhang Jianxun [3] et al. pointed out that the problems of ICT professional talents training in colleges and universities include (1) imbalance and misalignment between professional layout and ICT industry demand; (2) incompatibility between key elemental aspects of ICT talents training and social demand; (3) insufficient depth of integration of industry and education between colleges and enterprises, and put forward a series of improvement measures. Cen L[4] pointed out that the current computer science and technology professional The problems of construction include unbalanced curriculum system structure and ineffective curriculum implementation, and proposed to establish the basis of training objectives of computer science and technology majors, the value orientation of diversified and comprehensive curriculum objectives, and optimize the professional curriculum system. Liu Zhigang [5] and others explored the reform path of computer talents training in local industry colleges and universities and proposed a curriculum and practice system of "one body, two wings, three extensions and four modules" and a characteristic talent training model of "three layers of channels and four tractions". Wu Minghui [6] and others proposed a multi-driven, open and integrated model for training applied computer talents. In the face of changing talent needs,

they establish an agile curriculum system with competence-oriented and graded progression, build an overall design and "output-oriented" talent training path, and guarantee a support system led by famous enterprises and deep cooperation between industry and academia. You Lei[7] et al. proposed a model for cultivating applied computer talents in local colleges and universities in the context of new engineering, which is based on school-enterprise cooperation, building a professional talent cultivation program with subdivided professional directions, building a dual-teacher faculty with solid basic theory and rich practical experience, building a student-led classroom teaching mode with intergraded theory and practice, and building a multi-party cooperation practice base. Zhang Xian[8] and others explored and practiced the cultivation of applied talents for national first-class undergraduate majors in local colleges and universities by taking computer science and technology majors as an example, proposing the establishment of a cross-disciplinary application of bachelor degree talents cultivation pathway, promoting the reform of professional practice teaching in the same frequency and direction as the development needs of new engineering disciplines, and deeply integrating the collaborative cultivation of multiple parties from school, enterprise, government, local and industry.

Chen Changyao [9] analyzed the connotation of professional construction of higher academic continuing education, pointing out that social demand is the guidance of professional construction, curriculum construction is the focus of professional construction, and site construction is the guarantee of professional construction. Zhang Qiufeng[10] pointed out that the development of higher academic continuing education in China is not sufficiently invested, the quality assurance system is weak, the teaching is not well targeted, and the development of different education types is unbalanced, etc. In view of these problems, the author proposed to establish a service-oriented concept of higher academic continuing education, i.e. to design and transform the teaching contents to meet the needs of students, and to reform the teaching mode according to the characteristics of adult students. strengthen the market awareness of higher academic continuing education, as well as strengthen the construction of higher academic continuing education majors. Ma Guogang[11] and others analyzed the problems of higher academic continuing education in China and proposed the reform and development ideas of higher academic continuing education in general universities, which are to design cultivation plans with vocational characteristics with the guidance of effective supply of services, to create cultivation modes adapted to the characteristics of adult learning with the construction of a smart education system as the main line, and to build a perfect operation guarantee system with professional certification as the grasp.

To sum up, the cultivation of computer science and technology professionals cannot just be on paper, but requires the combination of practice and theory, and the grasp and analysis of the needs of computer disciplines and industry needs. In addition, the overall quality of the current higher academic continuing education still needs to be further improved. The School of Computer Science of China University of Geosciences (Wuhan) conducted a study on the construction of computer science and technology majors in higher academic continuing education from real data in view of the shortcomings of the current higher academic continuing education majors

in computer science, including the mismatch between the cultivated students and the job requirements of enterprises, and the failure of the cultivation program and learning contents to meet the needs of learners.

3 Analysis of competency needs for professional positions

3.1 General analysis of the professional post situation

In order to make the higher continuing education in computer science and technology to serve the trend of social and economic development to cultivate computer talents, it is necessary to clarify what kind of computer talents are actually needed by the current society, therefore, this section will analyze the professional job situation and interpret the current job demand situation.

The data for this analysis comes from the employment crawler data of computer science and technology majors provided by the School of Distance Education of China University of Geosciences (Wuhan), with a total of more than 90,000 entries. Jobs not related to computer science and technology majors, such as general factory workers, drivers and legal affairs, were excluded, and computer-related jobs such as technical consultants, software sales and product operations were retained, leaving a total of about 27,000 computer-related jobs data.

The results of the statistical analysis of the distribution of the above jobs by city and type are shown in Figures 1 and 2.

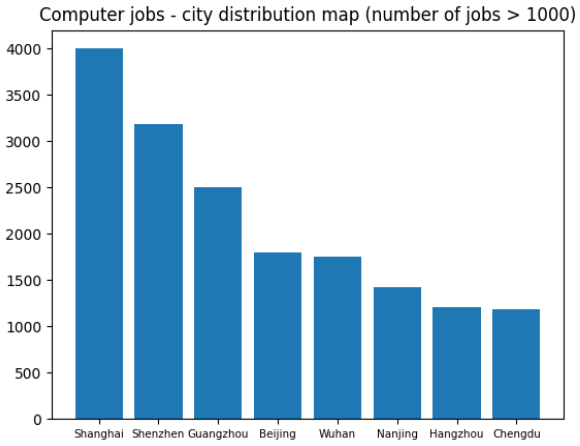

Fig. 1. City map of computer jobs

Figure 1 shows the distribution of computer science and technology jobs in cities. You can see that more than 50% of computer science and technology jobs are located in highly developed coastal cities such as North, Guangzhou and Shenzhen, while most of the rest are located in large inland cities such as Wuhan, Nanjing, Hangzhou and Chengdu.

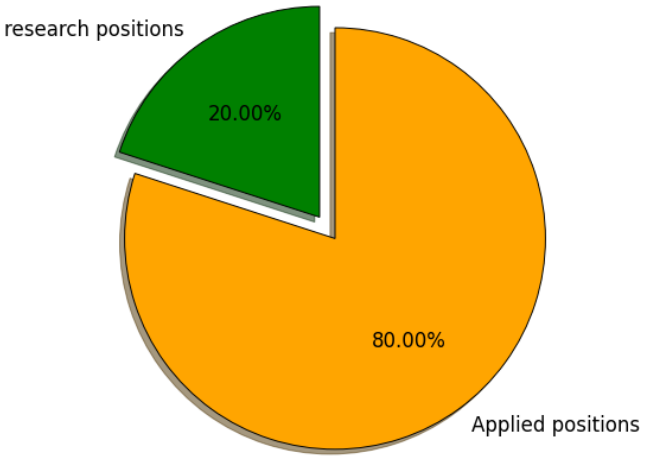

Fig. 2. Distribution of computer HF job categories

Figure 2 shows the statistics on the distribution of computer HF job categories. As can be seen from the graph, the computer industry has a much greater demand for application-oriented personnel than for research-oriented personnel. Moreover, high-frequency positions in the computer industry have high technical requirements, requiring candidates to have strong programming skills and to be familiar with programming and development work and the writing of technical documents for various projects, and to be able to complete technical work such as project implementation.

3.2 Analysis of competency needs for professional positions

Initial categorization of high-frequency positions, the main positions of market enterprises can be divided into technical, product and operational categories, plus 168 representative related positions selected from websites focused on IT industry recruitment data, continue to cluster analysis of positions, in the original job group filtered out some positions that need to focus on training as shown in Table 1.

Table 1. Classification of key training positions

Technical Category	*Product Category*	*Operation Category*
Front-end Development	Front-end Product Manager	Product Operations
Back-end Development	Backend Product Manager	
Mobile Development	Full Stack Product Manager	

An analysis of the competency requirements for the core job groups in the technical, product and operations categories in Table 1 yielded the following findings:

1) Competence requirements for technical job groups

For front-end development, generalist skills, software operation skills, network planning and diagnostic skills, and front-end development skills are the most important, followed by English and written writing skills and knowledge of data structures.

For back-end development, generalist skills, software operation skills, knowledge of data structures, and server-side development skills are most important, followed by network planning and diagnostic skills, basic mathematical knowledge, and English and written writing skills.

For mobile development, generalist skills, software operation, network planning and diagnostic skills, knowledge of computer systems, and server-side development skills are most important, followed by English and written writing skills, basic knowledge of mathematics, knowledge of data structures, and database application skills.

2) Competence requirements for non-technical job groups

The most important thing to look for in the product category is generalist skills, followed by English and written writing skills, software operation skills and product design skills.

Operations positions are most valued for general and operational skills, followed by English and written writing skills and software operation skills.

Through the above analysis of technical (including front-end development, back-end development, mobile development), product and operation positions, the competency requirements are summarized from the four aspects of general competency, professional basic competency, professional direction competency and management competency for the core group of computer positions, as shown in Table 2.

Table 2. Identifying key competencies in core job groups

Computer job group	*Front-End Development*	*Back-End Development*	*Mobile Development*	*Product*	*Operations*
General competencies	English and written writing skills, general quality skills, software operation skills				
Basic professional competencies	Mathematical analysis skills; data structure construction skills; network planning and diagnosis skills; database application skills	Ability to analyse mathematically; Ability to construct data structures; Network planning and diagnostic skills; Database application competencies; Computer system analysis	Ability to analyse mathematically; Ability to construct data structures; Network planning and diagnostic skills; Database application competencies; Computer system analysis	Mathematical analysis skills	Ability to analyse mathematically; Network planning and diagnostic skills; Database application skills; Computer system

Computer job group	*Front-End Development*	*Back-End Development*	*Mobile Development*	*Product*	*Operations*
		skills	skills		analysis skills
Professional orientation competencies	Front-end development skills; testing skills	Server-side development capabilities; testing capabilities	Front-end development skills; server-side development skills		Server-side development capabilities; testing capabilities
Management competencies	Project management skills	Project management skills	Project management skills	Product design capability; project management capability	Operational capabilities

By analyzing the competency needs of the core job groups, the teaching directions that should be focused on in the higher education continuing education major of computer science and technology are clarified, according to which the corresponding professional core courses and professional elective courses can be set, which provides a reference for the subsequent construction of the training program and curriculum system of the higher education continuing education major of computer science and technology, with greater social significance and value.

The competencies of core job groups and related courses are sorted out with corresponding knowledge, and the following knowledge list is obtained, as shown in Table 3. This knowledge list can provide a reference for the construction of the curriculum system of computer science and technology higher academic continuing education majors.

Table 3. List of applied job knowledge

Basic English for Computer Professionals	Principles of Computer Composition	Computer Assembly and Maintenance
Database Development and Applications	Website building and web design	Multimedia Design and Production
Computer Networking	Operating Systems	Computational Applied Mathematics
Java Programming	C# Programming	Graphic Image Processing
Information Security	Product Design Methods	Data Structures
Computer Network Fundamentals and Construction and Management of Local Area Networks	C++ Object Oriented Programming	Computer Graphics and Animation Design
C Programming	Computer Fundamentals	Software Engineering
Software Testing Techniques		

Through the above series of analysis, the important competencies of the core computer job clusters have now been obtained, including mathematical analysis ability, data structure construction ability, network planning and diagnosis ability, etc. According to the basic problems and objects of professional research in the discipline of computer science and technology, combined with the results of the analysis of the competency needs of the professional job situation, we have clustered and generalized the competencies for the training of computer science and technology professionals, and obtained the first-level competency needs of computer science and technology professional jobs, namely data acquisition and organization, data processing, modeling and algorithm design, and programming and software development competencies.

4 Analysis of the knowledge set of professional job competencies and engineering projects

In order to make the knowledge points included in teaching correspond better with those required by professional job competencies, and to cultivate truly usable technical talents for society, this chapter firstly starts from professional job competencies, decomposes the first-level competency system of computer science and technology professional jobs into the second-level and third-level competency systems, and further divides the knowledge units and analyses the knowledge points required to be learnt for the corresponding knowledge units; then from This chapter firstly decomposes the first-level competence system of professional posts in computer science and technology into the second-level and third-level competence systems, and further divides the knowledge units and analyzes the knowledge points required for the corresponding knowledge units.

4.1 Breakdown of the professional job competency system

Through the analysis of the computer science and technology professional job competency needs, the primary competency requirements of computer jobs have now been summarized. The first-level competencies of computer science and technology jobs are further extended and refined according to the scope or field of study of the discipline or profession, and the second-level competencies of computer science and technology jobs are obtained. Further decomposition of the second-level competencies will lead to the third-level competencies for computer science and technology positions. Part of the decomposition of the three-level competencies is shown in Figure 3.

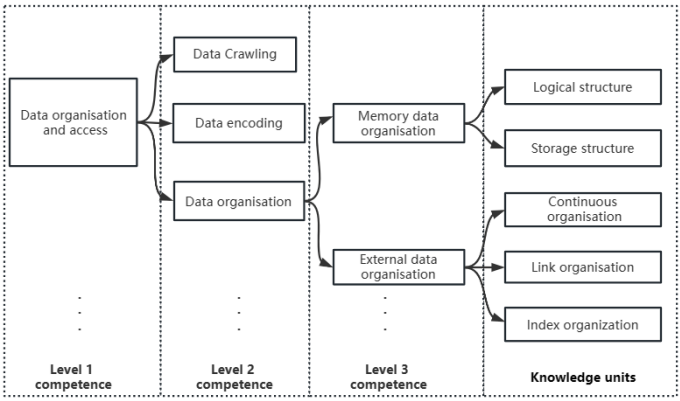

Fig. 3. Example of a three-tier competency system breakdown

The diagram above shows the breakdown of the three levels of competencies for professional positions. The purpose of the decomposition into three levels of competence is to identify the basic knowledge units, which are collections of knowledge that reach the three levels of competence for professional training and are based primarily on the knowledge competence map of the profession. The knowledge units can be further divided into smaller knowledge points. For example, the three-level competency "memory data organisation" contains the knowledge units "logical structure" and "storage structure", and the knowledge unit "storage structure The knowledge points contained in the knowledge unit "storage structure" are "chain storage structure" and "sequential storage structure". The computer job competence system is shown in Figure 4.

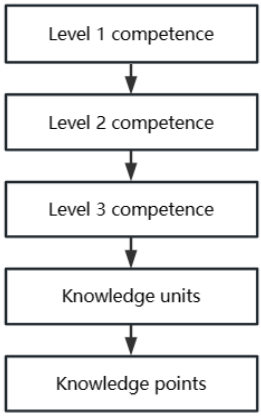

Fig. 4. Computer job competency system

Through the above analysis, the specific situation of the division of computer job competency system is as follows: the primary competency is divided into 4 aspects, namely data acquisition and organization, data processing, data transmission, programming and software development; based on the refinement of the primary compe-

tency, a total of 19 secondary competencies are obtained; based on the further division of the secondary competency, a total of 53 tertiary competencies are obtained; on the decomposition of the tertiary competency, a total of 53 knowledge units are obtained; the 53 knowledge units continue to be decomposed, a total of 260 knowledge points are obtained.

4.2 Deconstructing Engineering Project Teaching

In the computer teaching process, project-driven learning allows students to experience computer programming thinking and comprehend computer programming methods in a hands-on process, combining theory and practice to better enhance students' professional abilities and better train real computer application talents for society. The teacher can therefore design different projects to lead students in the teaching process.

As complete projects are often large and cover a variety of functional modules, and there are different connections between different functional modules, which are difficult for students to complete overnight, engineering projects can therefore be deconstructed into engineering examples to show the structural relationship between projects and engineering examples in a visual way, and to illustrate the training objectives covered by engineering examples; based on engineering examples, teachers can divide them into multiple teaching cases, and then list the knowledge points covered by the teaching cases[12]. Through the above steps, the project is decomposed and deconstructed in multiple layers to obtain individual knowledge points, and after learning the corresponding knowledge points, students can complete the module design and implementation of the corresponding project. The process of converting a project into a knowledge point is shown in Figure 5.

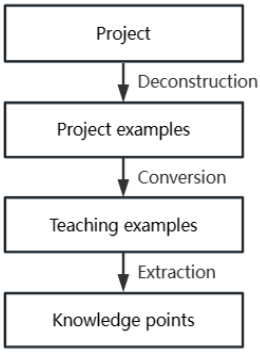

Fig. 5. The process of converting projects into knowledge points

The process of converting a project into a knowledge point is illustrated by the example of the "Academic Management System", part of which is shown in Figure 6.

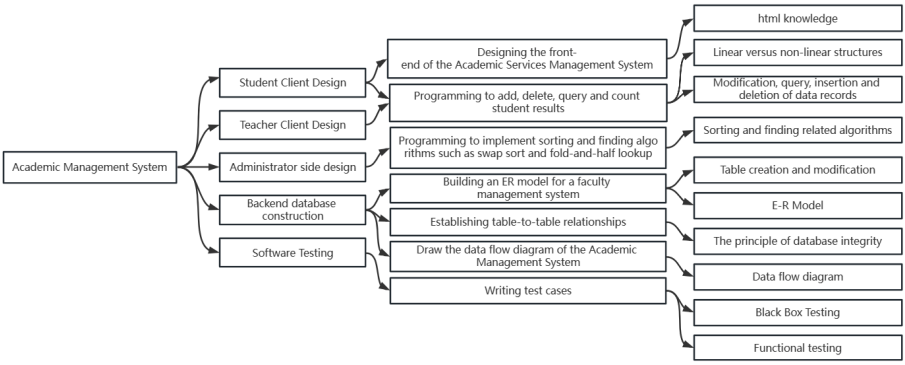

Fig. 6. The process of translating the "Academic Management System" into knowledge points

Through careful selection, we have chosen 4 engineering projects as teaching projects, which are B/S model-based library management system, movie website data mining system design and implementation, air passenger booking system, and network communication system. These four systems were decomposed in layers to obtain a total of 221 knowledge points.

4.3 A collection of knowledge points on professional job competencies and engineering projects

By deconstructing the professional job competencies in section 4.1, the knowledge points required to develop the corresponding professional job competencies have now been acquired. By deconstructing the teaching of engineering projects in section 4.2, the knowledge points required to learn and master the design and realisation of the corresponding projects have now been obtained. The knowledge points required for the development of professional job competencies are compared with the knowledge points required for the design of engineering projects in order to observe the intersection of the two knowledge points. The whole process of bringing together the knowledge points for professional job competencies and engineering projects is shown in Figure 7, and the knowledge points for specific projects and job competencies are brought together as shown in Figure 8.

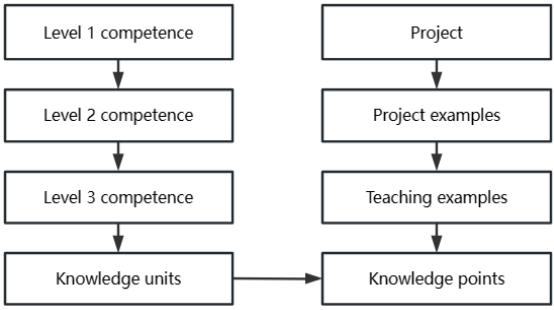

Fig. 7. The process of bringing together knowledge of projects and job competencies

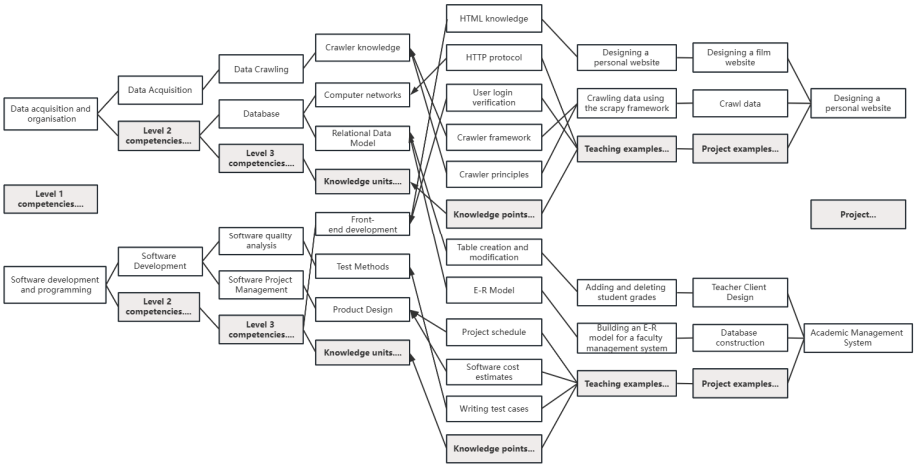

Fig. 8. Example of a collection of knowledge points on engineering projects and job competencies

As shown in the diagram, observation of the pooling of job competencies and knowledge points of specific projects can determine the appropriateness of the choice of engineering projects, as well as the range of knowledge points covered by existing projects, which can provide reference for the selection of the next engineering project, in order to set up more reasonable engineering projects and corresponding teaching cases, covering the core knowledge points as far as possible.

As an engineering project can obtain rich knowledge points through multi-layer decomposition, the knowledge points obtained after decomposition of several suitable engineering projects can overlap with the knowledge points of the professional job competence system, i.e. they can cover most of the knowledge points of the professional job competence system. After studying several engineering projects, students can have the corresponding professional job competencies, so that they can better meet the job requirements and social needs.

Based on the analysis of the knowledge points of professional job competencies and engineering projects, we have summarised four teaching engineering projects, which are B/S-based library management system, data mining system design and implementation for movie websites, air passenger booking system and network communication system. After decomposing these four projects, the knowledge points obtained are more than 80% of the knowledge points in the computer competency system, covering most of the knowledge points in the professional job competency system. Therefore, it is reasonable and effective to integrate these four teaching engineering projects into the teaching of professional construction.

5 Conclusions

In this paper, according to the job situation of computer industry, the important competency requirements of core job groups are obtained through analysis of job requirements, and the list of applied job knowledge is sorted out accordingly, which can provide reference for the construction of professional curriculum system of computer science and technology higher academic continuing education. Then the corresponding knowledge points are obtained by decomposing the professional job competencies; at the same time, four engineering projects are selected with project-driven teaching, and the corresponding knowledge points are obtained by deconstructing the projects. The knowledge points of the engineering projects were covered by more than 80% of the knowledge points of the professional job competency system, which proved the reasonableness and feasibility of the selection of the engineering projects.

In this paper, through the research and analysis of the professional job situation ability demand and the professional job ability and engineering project knowledge point pooling situation, the curriculum system construction of computer science and technology majors in higher academic continuing education and the construction of computer science and technology majors are improved, which provides new construction ideas for the cultivation of talents in computer science and technology majors in higher academic continuing education.

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