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Research on the construction of a "dual-collaborative" education system in computer-related majors based on data analysis

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Abstract: *In recent years, various universities have been actively exploring different education systems aimed at enhancing students' overall capabilities and meeting society's demand for labor force. This paper reviews the development of domestic research on the dual-collaborative education system over the past decade, highlighting the research hotspots and trends. The CiteSpace literature visualization software is used to visually analyze the knowledge map of literature data on the " dual-collaborative" theme in the CNKI Chinese database from 2013 to 2022. Sample data is analyzed for quantity, keyword co-occurrence, clustering, emergence, and timeline. Based on previous research, the authors propose a plan for the construction of a " dual-collaborative" education system, which achieves mapping among the "3+1" curriculum system, "1+1+N" extracurricular activities, and "three-stage" 100,000-line code training through the " dual-collaborative" mechanism both inside and outside the classroom and the school.*

Keywords: *Dual-Collaborative, Citespace, Visual analyses*

1. Introduction

The "dual-collaborative" education system, as a research hotspot in education and teaching reform, aims to cultivate computer-related professionals with strong theoretical foundations, practical abilities, and high overall quality. In order to meet the society's demand for labor force, universities are actively exploring corresponding education systems to enhance students' overall capabilities. Chongqing University has deepened the "Three-Comprehensives" comprehensive reform, constructed a new era high-quality talent training system, established the "Ten Major Educational Systems" and the "Six Major Educational Bases," constructed a stereoscopic and interconnected "Three-Comprehensives" system, and achieved all-round education[1]. By implementing the "Excellence Plan 2.0" as a grasp, they reformed and innovated mechanisms, comprehensively explored and implemented talent training paths under the "three-dimensional synergy, four-chain integration" teaching-enterprise integration mechanism, improved multi-subject synergy education mechanisms, and provided strong talent support for regional economic development and industrial transformation and upgrading. With the development of innovation and entrepreneurship education, society's demands for students' innovative and entrepreneurial abilities have been increasing[2].

However, some deeper issues in practical education for computer-related professions have gradually emerged, mainly manifested in the problems of difficult employment and lack of employees in enterprises, high educational background but low capabilities among computer-related professionals, and inadequate reform and innovation in the talent training system for the continuous updating of new technologies. To propose a "dual-collaborative" computer skills talent training program both inside and outside the classroom, this paper uses the visualization software CiteSpace[3] to analyze literature data from the past decade in China, including publication volume analysis, keyword co-occurrence analysis, cluster analysis, and emergent analysis . This analysis provides objective and effective information support for the talent training program[4,5].

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2. Data Sources And Research Methods

2.1. Data Source

The research data for this paper was obtained from the China National Knowledge Infrastructure (CNKI) database. A total of 267 studies were retrieved by setting the subject term to " dual-collaborative education system" and the time period to "2013-2022" using advanced search settings. The documents were sourced from journals such as Education and Teaching Research, Theory and Practice of Contemporary Education, Vocational and Technical Education, The Party Building and Ideological Education in Schools, Education Science, and China Higher Education. Within this range, strict screening of the documents was performed to remove articles not related to the dual-collaborative education system, including documents from conferences and newspapers, before arriving at a final decision[6,7]. A total of 256 articles were selected as research samples.

2.2. Research Method

This paper used the CiteSpace 5.8.R3 (64-bit) visualization analysis software[8,9] to conduct both quantitative and qualitative analyses on the retrieved CNKI data. Visual analysis was used to create charts on publication volume, keyword frequency, keyword co-occurrence, clustering, emergence, and timeline. Through extensive literature review, the progress and trends in the research on the dual-collaborative education system were further reviewed, and a feasible talent training program was analyzed and proposed.

3. Research Results And Analysis

3.1. Statistical analysis of publications

Research paper output has become an important marker of academic achievement and influence. By analyzing the number of publications and citations in a given field, one can assess the level of research and its development trends. Therefore, by counting the number of papers produced in the dual-cultivation system in China between 2013-2022, we can grasp its research trend. As shown in Figure 1, dual-cultivation research can be roughly divided into three stages in China: the initial development stage, from 2013-2017, when the understanding of dual-cultivation was still in its exploratory stage, resulting in a relatively small number of papers; the vigorous development stage, from 2018-2020, when dual-cultivation research was widely known and a large number of studies were published; and the stable development stage, from 2021 and beyond, when the publication rate of research papers on dual-cultivation showed a steady trend, indicating the saturation of research by domestic scholars. Over the past decade, the number of papers published on dual-cultivation in China has generally increased. Based on the current development trend, research interest in dual-cultivation in China is expected to continue.

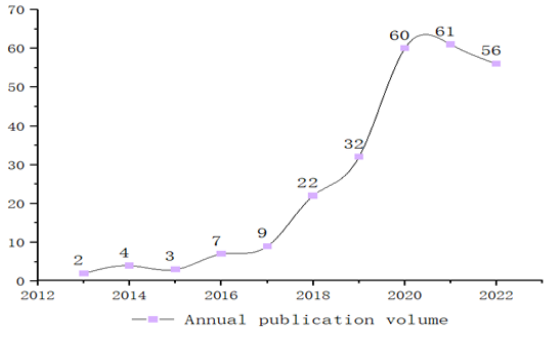

Figure 1: 2013-2022 Literature Publishing Statistics Chart

3.2. Keyword co-occurrence analysis

Firstly, the authors selected representative keywords and mutually related terms to reflect the core content of the article. When multiple authors selected the same keyword, it was deemed to be of particular importance. Based on this, CiteSpace 5.8 software was used to undertake co-occurrence analysis of keywords, to explore the research hotspots and development trends of the dual-cultivation system.

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Keykey was selected as the condition for merging and adjusting similar keywords. The resulting co-occurrence diagram of keywords is shown in Figure 2.

The central nodes of the network are important indicators of nodal centrality. From Figure 2, it can be seen that the hot topics and contents of the study included collaborative education, curriculum system, innovation and entrepreneurship, educational system, engineering capabilities, ideological and political education, and talent cultivation. This indicates that the development of the dual-cultivation system can benefit from the application and development of multiple educational and cultivation approaches. For example, collaborative education can promote cooperative learning among students, improving their learning effectiveness and abilities. Innovation and entrepreneurship education can cultivate students' innovative consciousness and practical abilities, laying a foundation for future innovation and development. Cultivating engineering capabilities can enhance students' practical abilities and problem-solving skills. Ideological and political education can cultivate students' sense of social responsibility and citizenship. Comprehensive talent cultivation can better meet society's needs and requirements for talent, making contributions to social development. Therefore, the dual-cultivation system should continue to be explored and researched in depth, in order to better adapt to the needs and development trends of society.

Figure 2: Co-occurrence knowledge atlas of domestic keywords

3.3. Cluster analysis

Clustering is a technique for grouping objects with small differences based on their similarities, while separating objects with large differences. To analyze the knowledge structure of the dual-collaborative education system more concisely and clearly, the data was imported into CiteSpace 5.8. A self-organizing map was generated, as shown in Figure 3. Three clusters were selected, including Collaborative Education, Ideological and Political Courses, and Innovation and Entrepreneurship, for further analysis based on keyword co-occurrence and clustering results in the field of dual-collaborative education system research.

As seen in Figure 4, for the Collaborative Education cluster, the research primarily focused on its role and specific practices in the dual-collaborative education system, such as how to construct a collaborative education system and how to catalyze students' collaborative learning abilities. Concerning the Ideological and Political Courses cluster, the main emphasis was placed on exploring its position and role in the dual-collaborative education system and how to implement ideological education into curriculum design and teaching practices, promoting students' ideological and political literacy. The Innovation and Entrepreneurship cluster was mainly studied in terms of its importance and practical approach in the dual-collaborative education system, analyzing how to cultivate students' entrepreneurial and innovative spirits, improve their engineering capability, and apply them to real-world scenarios.

Figure 3: Keyword cluster chart (overview)

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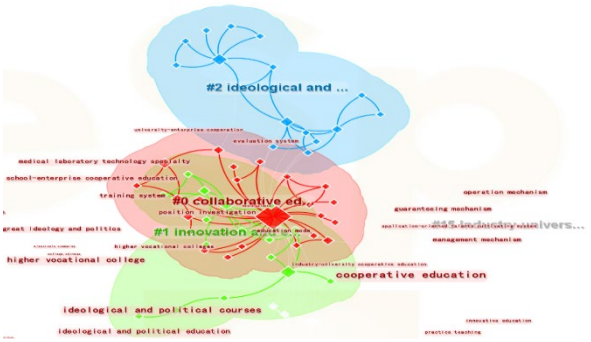

Figure 4: Keyword cluster plot (detail)

3.4. Keyword emergence analysis

Keyword emergence analysis is a methodology used to identify new topics or concepts emerging and developing within a specific research field. This approach involves identifying keywords with gradually increasing frequencies over time, which may indicate the emergence of a new research topic or trend. To investigate the degree of attention given to the dual-collaborative education system in various aspects, the data was imported into CiteSpace 5.8, and the top 25 keywords with the highest burst intensities were extracted and sorted by year, as shown in Figure 5.

Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2013 - 2022
application-oriented talents cultivating system	2015	0.68	2015	2015	
five in one	2015	0.68	2015	2015	
industry-academy-research cooperation	2016	0.65	2016	2016	
instructional projects	2016	0.65	2016	2016	
university-enterprise cooperation	2016	0.65	2016	2016	
medicine-education coordination	2016	0.65	2016	2016	
applied university	2016	0.65	2016	2016	
teaching methodology reform	2016	0.65	2016	2016	
talent training	2016	0.65	2016	2016	
college-enterprise cooperation	2016	0.65	2016	2016	
practice innovation	2017	0.65	2017	2017	
electronic commerce	2017	0.65	2017	2017	
medical laboratory technology specialty	2017	0.65	2017	2017	
school-enterprise cooperative education	2017	0.65	2017	2017	
course reform	2017	0.65	2017	2017	
training system	2017	0.65	2017	2017	
position investigation	2017	0.65	2017	2017	
cooperation education	2017	0.65	2017	2017	
school-enterprise collaborative education	2020	0.97	2020	2020	
education system	2020	0.92	2020	2022	
industry-education integration	2020	0.61	2020	2022	
home-school cooperation	2020	0.61	2020	2022	
talents cultivation	2021	1.04	2021	2022	
new engineering	2021	0.78	2021	2022	
ideological and political courses	2021	0.78	2021	2022	

Figure 5: Map of emergent domestic keywords

In terms of the appearance time of the keywords, "application-oriented talents cultivating system" and "five in one" were first seen in 2015, with similar burst intensities. Many keywords had a significant burst between 2016 and 2017, indicating an increased interest in research on the dual-collaborative education system. "school-enterprise collaborative education" appeared I n 2020 with a high strength value, suggesting that there were many relevant studies and discussions in that year about this concept, and indicating its importance and representativeness in the field. Meanwhile, the high or low strength value also reflected the level of research fervor for that keyword. The appearance of "education system", "industry-education integration", and "home-school cooperation" all occurred between 2020 and 2022, indicating increased attention to students' comprehensive development and societal needs, as well as the formation of ideas focused on educational system construction, industry-academia integration, and school-family cooperation.

4. Discussion

By analyzing and organizing the existing literature on the dual-coordinated education system, this paper proposes a development scheme for the dual-coordinated education system to address some of the

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underlying practical education problems faced by computer-related majors. These problems include a high unemployment rate for students and a shortage of skilled workers in the industry, the phenomenon of high education levels but low abilities among computer-related students, and insufficient innovation in talent training systems for new technology iterations. The proposed scheme utilizes a "bidirectional coordination" mechanism within and outside of the curriculum to map the "3+1" course system, "1+1+N" second classroom, and "three-stage" specialized training program for writing 100,000 lines of code. This scheme has been designed to address issues related to the development of applied talents and the high-quality employment process, with the aim of solving the pressing problem of unemployment among students and labor shortages for employers.

4.1. Establishment of a New Model of School-Enterprise Cooperation:

Four school-enterprise cooperation models, namely "coupling, embedding, introduction, and output", are proposed to support, assist, guide, and promote participation in four categories of educational activities, namely "theoretical teaching, laboratory guidance, course design, and internship assignments". Moreover, the participation will extend to four categories of extracurricular activities, namely "subject competitions, innovation projects, club activities, and the '100,000 Lines of Code' specialized training program".

4.2. Establishment of a "3+1" Education Model Curriculum System

The first three years will focus on fundamental skills training, and a practical education model combining production, learning, and research will be implemented for the fourth year. This education model aims to cultivate innovative, application-oriented, and versatile talents. The "3+1" model can promote further curriculum and teaching content reform, facilitate the transition towards a practice-oriented education mode, and leverage external educational resources from companies. It can also help students enhance their vocational competencies, professional practical training, and improve students' internship experiences, thereby facilitating direct employment in the internship units.

4.3. Implementation of an "1+1+N" Innovative and Entrepreneurial Education System

The "1+1+N" innovation and entrepreneurial education system requires students to engage in one innovation contest, one entrepreneurship project, and N disciplinary competitions. Through internal and external collaborative efforts, students must complete one innovation and entrepreneurship training course. Completing an innovation and entrepreneurship project helps alleviate the dire employment situation of college graduates, helps excavate students' enthusiasm for innovation and entrepreneurship, and paves the way to nurturing a large number of talented individuals with strong innovative abilities.

4.4. Completion of the Three-stage "100,000 Lines of Code" Training System

This training system targets computer-related majors, both on and off-campus, from courses to curriculum and school-enterprise integration, to the first and second classrooms are comprehensively restructured. The program emphasizes the development of students' effective coding skills, craftsmanship, and related capacities by addressing issues related to the effective distribution of code volume in terms of courses and time. Furthermore, the system aims to establish a comprehensive relationship between the quality and quantity of the code and the talent training, employment quality, and enhance the problem analysis ability, solution design ability, program design ability, communication and coordination ability of individuals and teams, project management ability, lifelong learning ability of computer science and technology undergraduate students. Multi-element evaluation of student codes is employed to reflect and correct existing deficiencies in the teaching system. This research result is optimized continuously through practices, applied to other computer-related majors, and subsequently combined with an engineering certification system to form a set of computer talent training systems for application-oriented undergraduate colleges.

4.5. Establishment of a "3+1" Education Model Curriculum System

A new model of computer vocational technology talent training is established with the combination of "academic certificate+100,000 lines of code proficiency certification," in which the combination of in-school theory education and out-school practical experience and guidance from the industry is included.

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4.6. Application Effect of Teaching Results

This plan was carried out from 2015 to 2017 and the results were implemented from 2017. Currently, it has covered approximately 2100 students from six sessions of the general higher education programs, adult higher education programs, and ISEC cooperative education programs. Nearly 15,000 students in the whole university have benefited from the computer basic courses. A total of 42 internal teachers, more than 30 teachers from other universities in China, and 12 engineers from various companies were trained. The research results were listed as provincial key pedagogical research projects, and they received two second prizes for provincial-level teaching achievements. During the pandemic, faculty members and students participated in the development of a local health code program. The independently-developed dormitory management application has become the main platform for the school to collect students' health data. The registration for the "volunteer service platform" reached 671,125 individuals, 4859 groups, and 1407 organizations. In the implementation process of the "Dual-Collaboration" education system, the employment rate and job quality of students have significantly improved, and the proportion of award-winning students in competitions has increased.

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