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Research Landscape of Sustainable Development of Digital Talents in the Era of Digital Economy

Liyao Ren[1], Jianxin Wu[2,*], Yi Wang[3]

[1,2]School of Culture and Education, Shaanxi University of Science and Technology, Xi'an 710021, China
[3]Yuwei Consulting (Shenzhen) Co., Ltd., Shenzhen 518000, China
[1]231412040@sust.edu.cn , [2]jianxinwu@sust.edu.cn , [3]wangyi@youwee.cn
**Correspondence Author*

Abstract: ***With the rapid development of global digital technology, digital transformation has become a clear trend in the complex and uncertain development of the current global economy and society, and the sustainable development of digital talents is undoubtedly the core element promoting digital transformation. Based on the literature on digital talent research over the past decade in the Web of Science database and the basic principles and methods of bibliometrics, this paper aims to systematically outline the knowledge graph of global digital talent research and its evolution path. The findings are as follows: Research on digital talents is divided into four stages: germination, preparation, growth, and stability, which generally reflect the urgent need for digital talents in the digital economy during the digitization process, gradually shifting towards a research trend where digital talents enable the sustainable development of the digital economy. Globally, Chinese scholars attach great importance to relevant research on digital talents, with their literature accounting for the highest proportion; 'Sustainability' is the most cited publication on digital talent. The research community on digital talents is relatively dispersed, with most scholars in a state of "independent exploration," and a long-term stable research community has not yet formed. Current research topics focus on three aspects: the training and development of digital talents, the application of big data and artificial intelligence technology in talent management and performance evaluation, and the skill requirements and career development paths of digital talents. For the high-quality development of the digital economy, global research on digital talents tends towards the systematic training, utilization, and management by governments, schools, and enterprises, emphasizing management talents with digital thinking and leadership, as well as the construction of digital talent training models, thereby enabling digital talents to foster the sustainable development of the digital economy.***

Keywords: Digital economy, Digital talent, Sustainable development, Digital transformation**.**

1. Introduction

In recent years, all kinds of new formats, new models, and new industries are more or less pointing to the keyword "digital economy", and the driving force behind it is the traction of data, which all proves that the digital era has arrived. In this context, digital talent, as the core bridge connecting data and technological innovation, has become a key force in promoting the vigorous development of emerging industries, accelerating the change of business models, and enhancing global competitiveness, which determines whether enterprises and countries can occupy the strategic high ground in the wave of digital economy. Some authoritative international institutions have also issued reports on digital talent research, and these high-quality research results are enough to illustrate the impact of digital skills on sustainable human development. For example, the Global Talent Trends report released in 2024 by Mercer, the world's leading human resources consulting firm, suggests that the rapid rise of artificial intelligence forces companies to take the opportunity to re-examine their productivity models. Companies must consider the role of new digital technologies in empowering employees, increasing efficiency, and driving personalized innovation in business solutions and employee experiences [1]. According to the Future of Jobs 2023 report released by the World Economic Forum in April 2023, big data, cloud computing, and artificial intelligence play an important role in the adoption potential of technology applications. More than 75 percent of companies expect to adopt these technologies within the next five years [2]. Despite the rapid development of the digital economy, the shortage of digital talent has become a key bottleneck limiting industrial innovation and economic growth. To accelerate the training of digital talents and give full play to the basic role of digital talents in supporting the digital economy, China, the United States, Germany, and other countries have formulated digital talent development plans and proposed action plans for digital talents to empower the sustainable development of the digital economy effectively. Digital transformation is advancing in an orderly manner, and the introduction of digital technology provides new momentum for industry enterprises, which objectively requires the effective supply of high-quality professional digital talents. In the field of agriculture, digital technology can improve agricultural production efficiency and promote the development of smart agriculture. In the medical field, digital technology can promote the popularization of telemedicine and precision medicine, and improve the accessibility and quality of medical services; In the field of transportation, digital technologies can optimize traffic management systems and improve the efficiency and safety of transportation [3-5]. In the future, the development of digital talent should focus on sustainability, both to develop talents with high-level digital skills and to ensure that these talents can cope with the changing technological environment and have the ability to learn for life [6]. How to ensure that the quantity and quality of digital talents can meet the needs of the digital economy era and escort its development has become a practical issue that we urgently need to discuss and study.

The current understanding of digital talent can be summarized in the following two definitions. From the perspective of the development of the digital age, researchers can not limit the definition of digital talent to ICT professional skills but need to define digital talent from a broad perspective. The first broad definition is based on the OECD's classification of ICT (information and communication technology) skills.

According to OECD standards, digital talent can be divided into those who have ICT expertise and those who have complementary and synergistic skills with ICT expertise. ICT expertise mainly covers a range of professional skills needed to develop ICT products and services, such as programming, web design, e-commerce, big data analytics, and cloud computing. Complementary ICT skills refer to the ability to use specific digital skills or platforms to help solve relevant problems at work, including processing complex information, communicating with stakeholders, and providing solutions. The second narrow definition, that is, talents who meet the development needs of the digital age and have digital skills, are also often referred to as digital talents. According to their own needs, digital talents are divided into four categories: digital leader talents, digital management talents, digital application talents, and digital professionals [7]. Detailed definitions of digital talents can not only clarify the skills and knowledge required by digital talents at different levels and directions but also guide individuals in career planning and skill improvement. It can also help higher education and enterprises clarify training goals, so as to formulate targeted training and education plans [8].

From the existing literature, there are many research results on digital talents, mainly focusing on the definition of digital talents, digital skills to be possessed, innovation and collaboration consciousness, and the construction of a training system, providing a reference for understanding digital talents [9-12]. However, most of the research is case-oriented, the research perspective is not holistic, there are limitations in the discussion and research of digital talents, and they do not well show how digital talents can promote sustainable economic and social development [13-15]. In fact, digital talent, including data scientists, IoT engineers, blockchain developers, cloud computing experts, cybersecurity analysts, and others, is a key factor in national competitiveness [16,17]. The digital divide, inclusiveness, and equity brought about by the cultivation of digital talents also need our continuous in-depth study [18-21]. At present, researchers lack a systematic review of the research results on digital talents and should stay in the process of research appropriately to review and reflect on past research. Based on this, this study conducted an in-depth analysis of the digital talent literature collected by Web of Science in the past 10 years from a global perspective. By displaying the keyword knowledge graph of digital talent-related literature, this paper analyzes the current research hotspots and research trends of digital talent, providing direction and reference value for future research on digital talent content itself, and promoting the sustainable development of digital talent and social economy.

2. Methods and Materials

2.1 Research Methods

This study is based on the basic principle of bibliometrics, using the knowledge graph method and co-occurrence analysis method. Bibliometrics is a quantitative research method that studies the structure, characteristics, and laws of scientific research implied by the external characteristics of literature. The knowledge graph method is an interpretation method that describes knowledge resources and their carriers by visualization technology, and repeatedly excavates, analyzes, constructs, and displays knowledge and its interrelations. The knowledge graph method can be used to analyze the structure of literature knowledge and explore future research hotspots and research trends [22-24]. The essence of co-occurrence analysis is to make pair statistics on the frequency of occurrence of a group of words in the same article and carry out cluster analysis on these words, to further analyze the internal research changes of the disciplines and topics represented by these words. Bibliometrics co-occurrence analysis techniques can also explore topics in the emerging field of digital talent research [25-27]. By using the knowledge graph method and co-occurrence analysis method, this paper comprehensively combs the research results related to digital talents through quantitative and visual means, helping to identify research hotspots, key authors, and their research trends, to provide theoretical support and practical guidance for subsequent research.

The software for quantitative analysis of knowledge graph documents used in this study is VOSviewer, developed by the Science and Technology Research Center of Leiden University in the Netherlands. It displays cluster knowledge graph, density knowledge graph, and superimposed knowledge graph according to the difference of key node spacing, density, and size, to analyze and predict the current research direction, research hotspot, and future research trend [28-30]. In addition to the visualization software based on VOSviewer, this study also uses Flourish and other systems to conduct statistical and in-depth research on the country of publication, citation times, and published journals of the research literature, to explore the development and research status of digital talents from a global perspective and predict the trend of future development of digital talents.

2.2 Data Source

The data in this study were collected from the literature on digital talent research in the core database of Web of Science in the past ten years, and the search time was June 24, 2023. Search for the keywords “digital talent”, “digital professional”, “digital human resource”, “ICT talent” and “ICT professional”. In this study, the WOS advanced search function is used, that is, a search formula is created by field identification, Boolean operation, parentheses, and search result set, where TS represents the topic, and the final search syntax is: TS= (“digital” OR “ICT”) AND TS= (“talent” OR” professional” OR “human resource”). The number of documents obtained in the preliminary search was 6,100. Since the paper was written in 2024, the number of documents retrieved in 2024 does not represent the total number of documents for that year. Therefore, the author selected the search period from 2014 to 2023 and obtained 4812 documents in the past decade. Finally, by reading the title and abstract, the author eliminated the articles unrelated to digital talent and digital talent training, as well as the articles suspected of repeated publication, and obtained 233 articles for research and analysis. The selection process is shown in Figure 1. The contents of the obtained file are complete records and references, and the exported file format is a plain text file. Finally, we import VOSviewer software, remove irrelevant keywords, and present a visual literature knowledge map.

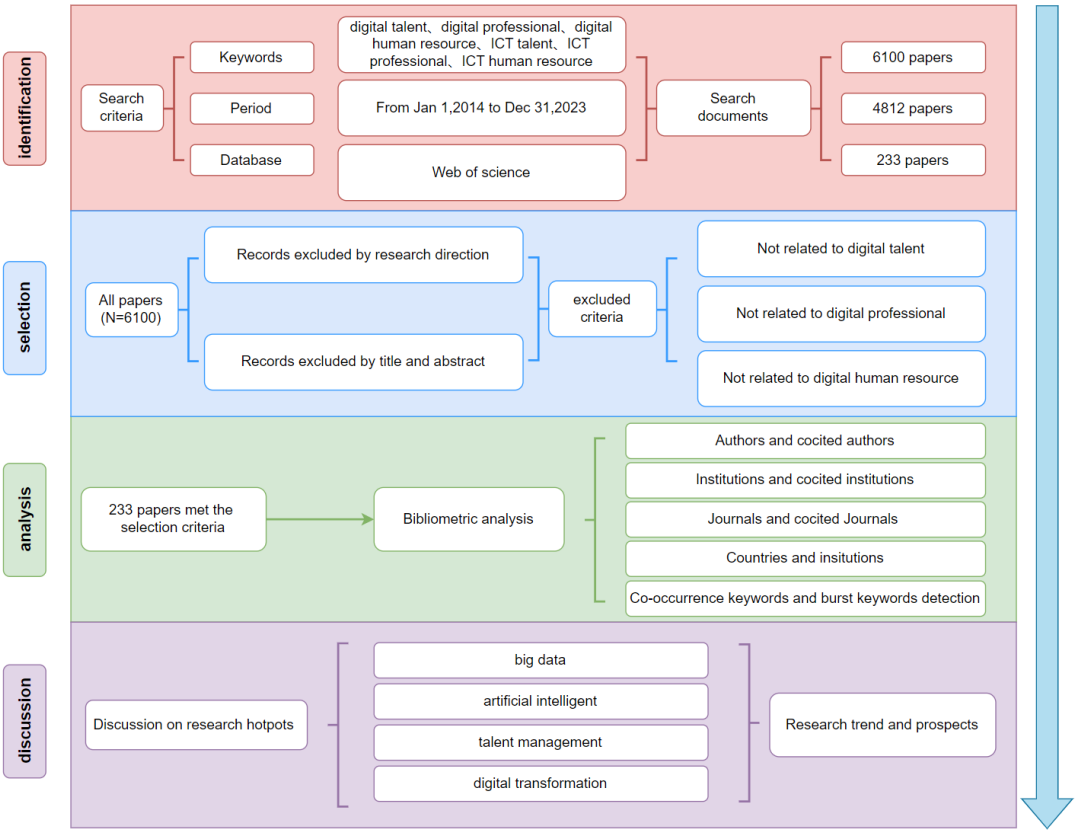

Figure 1: Literature screening process

2.3 Limitations of Research Data

We only analyzed the relevant results of digital talent research in the Web of Science database, and the analysis did not include the relevant results in other databases, which is the limitation of our research. It is worth noting that we will take the literature on the theme of "digital talent" as a research sample to conduct a comprehensive study of the current research status and provide inspiration for the sustainable development of digital talent from a global perspective. Digital talent research reveals the profound impact of digital technologies on all sectors of society and helps planners and managers understand the practical applications and challenges of these technologies. This kind of research not only drives deep thinking in the industry about digital transformation but also facilitates the identification of emerging skills and talent needs. By systematically analyzing the application of digital technologies, digital Talent research helps develop strategies to develop innovative and adaptable talent to better address the complex challenges and opportunities of the intelligent age. This kind of research is of great significance to education, enterprises, government, and other levels, and can promote the overall digital development of society and the optimization of human resources.

3. Content Analysis of Digital Talent Literature

The digital economy is closely intertwined with the fields of artificial intelligence, education, industry, and human resources. In the field of artificial intelligence, digital talents are the key force to promote technological innovation, with professional algorithms, model building capabilities, to build a solid technical foundation for the digital economy; the field of education, as the "cradle" of digital talents, needs to innovate the education system, and constantly deliver the professionals needed by the digital economy; industry is entering the 4.0 era, digital talents lead the digitalization and intelligent transformation of production processes, and integrate digital technology to improve efficiency, optimize products, expand models, and help enterprises compete in the digital wave; industry As industry enters the 4.0 era, digital talents will lead the digital and intelligent transformation of the production process, and the integration of digital technology will enhance efficiency, optimize products, expand models, and help enterprises compete in the digital wave; the human resources field will be transformed by the digital economy, and the accurate management of digital talents will become the key to enhance the competitiveness of enterprises. As shown in the Future Employment Report released by the World Economic Forum (WEF), the digital economy is booming, the global demand for digital talents is blowing up, and the shortage of talent is becoming a bottleneck for the development of digitization and the digital economy in various fields, which shows that it is imminent to strengthen the cultivation of digital talents, and to promote the in-depth integration of multiple fields with the digital economy.

3.1 The Role of Digital Talent in the Artificial Intelligence Field

This section focuses on digital talent in the field of artificial intelligence, and the scope of research covers the application of artificial intelligence in talent identification and human resource management practices, teaching experiments in digital talent development, and strategies and ecosystem building for digital talent development.

Table 1: The role of digital talent in AI

thematic	Thesis title	focus
Digital Talent-Driven AI Industry Applications and Impacts	The pace of artificial intelligence innovations: Speed, talent, and trial-error Artificial intelligence applied to potential assessment of talent identification in an organizational context Artificial Intelligence (AI), the Future of Work, and the Building of a National Talent Ecosystem ……	Focuses on digital talent to drive AI adoption across multiple industries and explores its impact and value on work systems, technology adoption, and national development.
Digital Talent and Artificial Intelligence Professional Competency Development	Is AI Better Than Humans in Identifying High-Potential Talents? A Quasi - Field Experiment Application of Artificial Intelligence in Human Resource Management Practices	Explore competency enhancement and application of digital talent and artificial intelligence around their professional competency linkages in talent identification and human resource management practices.
Artificial Intelligence Teaching and Experimentation for Digital Talent Development	Teaching Agile Software Development Using Agile Methods: A Case Study A Flexible Remote Laboratory Platform for Interactive AI Experiments with Hardware and Software Facilities ……	Focus on the practice and exploration of AI teaching methods, experimental platforms, and open source resource utilization with the goal of digital talent cultivation.
Artificial Intelligence Strategies and Development Led by Digital Talent	Winning AI Strategy: Six Steps to Create Value from Artificial Intelligence Algorithm Power or Punishment: Information Worker Perspectives on Passive Sensing Enabled AI Phenotyping of Performance and Wellbeing ……	Focuses on digital talent to lead AI development strategies, covering development points such as value creation, strategic planning, algorithmic impact, and talent employment.

The above-published academic papers focus on the key role of digital talents in promoting the development process of artificial intelligence. The core viewpoint clearly points to digital talents as the core driving force of AI. At the level of technology research and development, by virtue of profound professional knowledge reserves, such as proficiency in machine learning algorithms, deep learning architectures and other cutting-edge technology fields, they can provide intellectual support for the breakthrough of technical bottlenecks in AI, accelerate algorithm optimization, model innovation, and promote the performance of AI systems to achieve a quantum leap; in the dimension of application expansion, digital talents can In the dimension of application expansion, Digital Talent can accurately understand the pain points and needs of various industries, and skillfully integrate AI technology into multiple scenarios such as medical, financial, and manufacturing industries, such as realizing accurate disease diagnosis assistance in the medical field and intelligent risk control in the financial field, so as to broaden the boundaries of AI application; in the link of industrial ecological construction, Digital Talent takes the lead in building a bridge for cooperation between industry, academia, and research institutes, to promote the sharing of knowledge and the transformation of technology, and to attract more resources into the field of AI, helping to build a complete and active industry. This will help create a complete and active industrial ecosystem and promote the development of AI in all aspects.

Critically examining the above research results, there are still some urgent improvements. From the perspective of the talent cultivation system, the study fails to discuss how to build a long-term mechanism for digital talent cultivation that meets the needs of the rapid development of artificial intelligence, and fails to study how to dynamically adjust and optimize the curriculum system of colleges and universities, and how to make up for the gap between theoretical learning and practical application, so as to ensure the continuous delivery of high-quality digital talents; focusing on the level of cross-field collaboration, the study neglects to study the communication barriers, knowledge structure differences and other obstacles in the process of collaboration between digital talents and traditional industry experts. Focusing on cross-domain collaboration, we have neglected to study the communication barriers and differences in knowledge structure between digital talents and traditional industry experts in the process of collaboration, and failed to give practical strategies to break the barrier, which affects the efficiency of AI technology taking root in traditional industries; Focusing on social and ethical considerations, we have paid insufficient attention to the ethical disputes over data privacy and algorithmic bias triggered by AI under the leading role of digital talents, and failed to analyze the root causes behind the problem systematically and put forward an effective approach to standardize and guide the development of AI. It has not systematically analyzed the root causes and proposed effective solutions to regulate and guide the development of AI, which has posed hidden dangers for the sustainable development of AI.

3.2 The Role of Digital Talent in the Field of Education

This section analyzes the cultivation mode and curriculum structure of digital talents, explores the application of digital technology in the process of cultivating educational talents, and discusses the multiple dimensions of educational development strategies, tactical suggestions, and actual cases.

Table 2 The role of digital talent in education

Table 2: The role of digital talent in education

thematic	Thesis title	focus
Digital Talent Development Model and Curriculum-Related	A Digital Governance and a Boost for College Talents Training under the rural revitalization in China - a case study of Yixian County (China) A Systematic Review of Data Analytics Job Requirements and Online - Courses Research on the Training Model of E - Commerce Professionals Based on Big Data Analysis ……	Focusing on the innovation of digital talent cultivation mode and curriculum construction, exploring cross-domain cultivation path, teaching method innovation and curriculum system optimization.
Digital Technology in Educational Talent Development	Partner Differential Education - Assisted Accounting Professional Education and Training Artificial Intelligence Collaborative Course System Construction Applying Blockchain Technology to Develop Cross - Domain Digital Talent Cultivate an Innovative Blended Model to Develop Cross - Domain ICT Talent for University Courses ……	Focuses on digital technology-enabled education talent development, covering intelligent teaching systems, talent assessment and development, and multi-disciplinary integration applications.
Strategies,	Research on the cultivation of intelligent transportation technology Professionals under the	Focusing on the strategy of promoting education

recommendations and cases for digital talent and education development	Background of Integration of Production and Education Training Model of Innovative Accounting Talents in Colleges Using Artificial Intelligence Research on the Cultivation of Engineering Talents in Software Major between Universities and Enterprises Based on the Perspective of Big Data ……	development by digital talents, it provides implementation suggestions, analyzes typical cases, and helps build the ecology of education talents.

The above study has launched a multi-dimensional discussion around digital talent cultivation and development. In terms of digital talent cultivation mode and curriculum, it emphasizes the adoption of a systematic curriculum system and innovative learning modes, such as the development of learning maps for cultivating cross-disciplinary digital talents and the e-commerce professional talent cultivation mode based on big data analysis, in order to satisfy the industry's demand for composite talents. The application of digital technology in the training of educational talents highlights the use of artificial intelligence, machine learning, and other technologies to realize personalized teaching and accurate talent training, such as partner differentiated education to assist accounting professional education, personalized intelligent education system based on entropy power and TOPSIS method, etc. The section of Strategies, Suggestions, and Cases of Digital Talents and Education Development, covers the research on the cultivation strategies from intelligent transportation technology professionals to talents in the film and television industry, as well as practical explorations such as predicting the teaching effect and optimizing the allocation of educational resources through the Internet of Things, big data and other technologies.

Despite the fruitful results of the above research, there are still some aspects that have not been fully paid attention to. First, there is a lack of adaptability of the macro-environment of talent cultivation, and fewer studies have explored how the digital talent cultivation mode dynamically adapts to the rapidly changing socio-economic and policy environment, such as the impact of policy adjustments in emerging industries on the structure of the demand for digital talents and the corresponding changes in the cultivation mode. Secondly, there is insufficient research on the sustainability of talent cultivation, and there is a relative lack of research on the mechanism of continuing education and capacity enhancement of digital talents at different stages of their careers, as well as how to build a lifelong learning system to cope with technological iteration. Third, under the perspective of social equity, there is a lack of research on the gap in access to digital education resources among students from different regions and classes, as well as discussions on how to promote educational equity and ensure equal opportunities for digital talent cultivation by means of educational policies and technologies.

3.3 The Role of Digital Talent in the Industrial Sector

This section focuses on the multiple roles of digital talents in the industrial context: at the level of Industry 4.0 management and strategy, it involves human resources practice, failure factor analysis, maturity model construction, etc.; at the dimension of digital economy and industrial development, it explores the talent concentration effect and its impact on regional green technology innovation, etc.; in the field of industrial digital transformation and innovation, it focuses on their roles in enterprise recruitment, innovation capability shaping, etc.; in addition, it also covers the interrelationship between specific industries or enterprises, talent decision-making, behavior measurement, and technologies such as cloud computing and IoT, and industrial and digital talents. In the field of industrial digital transformation and innovation, it focuses on its role in enterprise recruitment, innovation capability shaping, etc. In addition, it also covers talent decision-making and behavior measurement of specific industries or enterprises, as well as the interrelationship between cloud computing, the Internet of Things and other technologies and industrial and digital talents.

Table 3: The role of digital talent in industry

thematic	Thesis title	focus
Industry 4.0 and Digital Talent-Related Management and Strategies	Human resource practices accompanying industry 4.0 in European manufacturing industry An Employee Competency Development Maturity Model for Industry 4.0 Adoption The Concept of Talent Management in the Era of the Fourth Industrial Revolution as the Basis for Sustainable Development Inducement factor of talent agglomeration in the manufacturing industrial sector: A survey on the readiness of Industry 4.0 adoption ……	Focus on digital talent management practices, failure factors exploration, competency development models and talent pooling strategies in the context of Industry 4.0.
Digital economy, technology and industrial development and talent linkages	Adaptive talent journey: Optimization of talents' growth path within a company via Deep Q - Learning Research on the impact of digital economy on Regional Green Technology Innovation: Moderating effect of digital talent Aggregation Leveraging Big Data Technology for Small and Medium - Sized Enterprises (SMEs) ……	Focusing on the impact of the digital economy on industry, it explores the role of digital technologies to fuel business growth and the role of digital talent in regional innovation.
Digital transformation and innovation in industry and the role of talent	The fourth industrial revolution, an opportunity for Civil Engineering Trends in Recruitment Information and Communication System using Artificial Intelligence in Industry 4.0 ……	Analyzing the role and impact of digital talent in recruitment and decision-making around digital transformation and innovation in industry.
Industry or business-specific digital talent-related research	A Decision Model for Talent related challenges in the Telecom Sector in India Digital Mindset & Behavior Measurement in a Large Digital - Telco Company	Focusing on the challenges, thinking and behavioral measurements of digital talent in specific industries and companies, it provides a reference for talent management in the industry.

The above article explores the connection between digital talent and industrial development from multiple perspectives. In terms of management and strategy related to Industry 4.0, they focus on the human resource practices of the European manufacturing industry along with Industry 4.0, analyze the key factors that promote Industry 4.0, construct the maturity model of employee competence development, take the concept of talent management as the basis of sustainable development, and also investigate the inducing factors of talent concentration in the manufacturing industry. In terms of

the digital economy, technology and industrial development and talent association, we study the impact of the digital economy on regional green technology innovation and the moderating role of digital talent agglomeration, explore the development of small and medium-sized enterprises (SMEs) with the help of big data technology, and optimize the growth path of talents through in-depth Q-learning. In terms of digital transformation and innovation in industry and the role of talent, it analyzes the impact of digitalization on dual innovation in manufacturing companies, explores the trend of artificial intelligence used for recruitment, and the talent-related challenges faced by specific industries such as civil engineering and telecommunications. Also covered are the challenges of the application of emerging Industry 4.0 and IoT technologies in the Ghanaian construction industry, the role of cloud computing in managing big data in organizations, and the relationship of other technologies to industrial and digital talent such as talent attraction in the context of manufacturing skills.

Despite the richness of the above research results, there are still some limitations. In terms of cross-cultural integration, most of the research focuses on specific regions or industries, and lacks a systematic comparison of the differences in digital talent management and Industry 4.0 implementation in different cultural contexts, making it difficult to form a universal cross-cultural industrial talent development strategy. From the perspective of technological ethics, there is an insufficient exploration of ethical issues such as algorithmic bias and data privacy infringement in the application of AI in recruitment and other applications, and the potential risks have not been adequately assessed and countermeasures have not been proposed. In terms of talent ecosystem construction, less attention has been paid to the synergistic mechanism between digital and traditional industrial talents, and how to create an ecological environment that promotes the integration and development of the two types of talents, to better promote the comprehensive digital transformation of industry.

3.4 The Role of Digital Talent for Human Resources Management

This section examines the roles and competencies of digital talent in big data and human resource management, the application of digital technologies in various aspects of human resources, the digital transformation of human resources and the development of digital talent, as well as digital ethics and digital talent acquisition in human resources.

Table 4: The role of digital talent in human resources

thematic	Thesis title	focus
Digital Talent Roles and Competencies in Big Data and Human Resource Management	Human resources for Big Data professions: A systematic classification of job roles and required skill sets	Focusing on the role positioning of digital talents in big data human resource management, competence requirements and the enhancement of enterprise decision-making ability.
	Steps Towards Bridging the HR and Computational Science Talent Gap on Ontology Engineering Methods	
	……	
Application of digital technology in all aspects of human resources	Analysis on the Demand of Top Talent Introduction in Big Data and Cloud Computing Field in China Based on 3 - F Method	Focus on the innovative application of digital technology in various aspects of human resources such as talent management, teaching quality assessment, and introduction of high-end talents.
	Big Data and Predictive Analytics: A Facilitator for Talent Management	
	Machine Learning Based Method for Decision Making Value of Talent from digital traces to competences	
	……	
HR Digital Transformation and Digital Talent Development	The effect of ICT Adoption on Corporate Governance: The Moderating Role of Human Resource Quality	Explore the development and role of digital talent in interdisciplinary project management and industry change around the trend of digital transformation in HR.
	Talent Management of Transdisciplinary Roles in Digital Projects: Designing a Business Technology Management Body of Knowledge	
	……	
Digital Ethics and Digital Talent Acquisition in Human Resources	Pitfalls and Tensions in Digitalizing Talent Acquisition: An Analysis of HRM Professionals' Considerations Related to Digital Ethics	Focuses on digital ethics in HR and how to balance ethics and digital technology applications in the talent acquisition process.
	3D Face Recognition Neural Network for Human Resource Recruitment	

The above article is a multidimensional study centered on digital talent and human resource management. In terms of the roles and capabilities of digital talents in big data and HRM, they clarify the job roles and skill set classifications of big data careers, analyze the dynamic capabilities of enterprises to improve the decision-making ability and quality of big data, explore the ontological engineering approach to bridge the gap between human resources and computational science talents, as well as illustrate the impacts of digital transformation on HRM. On the application of digital technology in various aspects of human resources, it covers the optimization model of human resource management in cloud-edge computing, the expected application of emerging technologies in human resource management, the human resource allocation scheme of big data in digital media based on recurrent neural network, big data, and predictive analytics to help talent management, and the value judgment of talent decision-making based on machine learning, and so on. At the level of digital transformation of human resources and digital talent development, it explores the impact of ICT adoption on corporate governance, the role of digital transformation of human resources, and talent management for interdisciplinary roles in digital projects. Digital ethics and digital talent acquisition in HR are also covered, including ethical considerations and related tension analysis in digital talent acquisition, and HR recruitment applications based on 3D facial recognition neural networks.

Despite the richness of the above research results, there are still some shortcomings. At the macro level, there is a lack of systematic comparative research on the digital transformation of human resources in different countries and regions, which makes it difficult to clarify the commonalities and differences of the transformation in different cultural and policy contexts and is not conducive to the formation of universal transformation strategies. From the perspective of talent cultivation, there is insufficient research on the long-term career development path of digital talents and the dynamic adjustment of the cultivation system, and insufficient consideration of the continuous changes in the ability requirements of talents due to the rapid iteration of technology. In terms of ethical research, although the issue of digital ethics

has been paid attention to, there is a lack of in-depth and practical discussion on how to build an effective ethical regulatory mechanism and guide enterprises and human resource managers to follow ethical norms in practice. Meanwhile, in the process of integrating human resource management with digital technology, research on the psychological and behavioral changes of employees is relatively weak, failing to comprehensively assess the potential impact of the application of technology on employees' job satisfaction, organizational identity and other aspects.

4. Current Situation of Digital Talent Development

4.1 Age Distribution and Stage

This section uses bibliometrics to make statistics and analyses on the annual publication volume of digital talent-related literature. Specifically, the final selection of articles is classified by year, and the number of articles published each year is calculated as a proportion of the total number of articles published. Figure 2 shows the final analysis results.

Figure 2: Quantity of digital talent literature from 2014 to 2023.

As can be seen from Figure 2, the number of papers related to digital talents increased with the increase of years, but there was a downward trend in 23 years. Therefore, the development process of digital talent research can be divided into four stages: the germination period (2014-2015), the preparation period (2016-2018), the jump period (2019-2022), and the plateau period (2023).

The first stage is the embryonic stage of digital talent research (2014-2015). Before this period, although digital technology developed steadily and literature on digital talent was published, there was no substantial breakthrough in the research. In 2012, 3D printing technology achieved remarkable results, gradually progressing from prototype manufacturing to actual production [31,32]. The proliferation of big data technologies and Cloud computing platforms, such as Amazon AWS, Microsoft Azure, and Google Cloud, allows enterprises to process and analyze vast amounts of data, driving data-driven decision-making and business development [33-35]. 2013 saw breakthroughs in deep learning technologies, particularly AlexNet's performance in the ImageNet competition, leading to a rapid expansion of neural network applications in areas such as image recognition, speech recognition, and natural language processing [36]. The above technological development has attracted the attention of scholars from all over the world, and the research on digital talents is gradually popularized. In 2014-2015, the research results of digital talent rose slowly, but the number of studies was very small, and the research field was relatively dispersed. At this stage, the research on digital talents is mainly represented by scholars who are interested in emerging digital technologies, mainly focusing on big data, 3D printing, and the cultivation and management of ICT talents in higher education, without forming an independent professional research team and knowledge system [37,38].

The second phase is the preparation period for digital talent research (2016-2018), during which the Internet of Things technology has received widespread attention and rapid development. This is inseparable from the development of digital technology and the support of national governments. In the process of promoting the development of digital technologies, the government plays a key guiding and supporting role in building and maintaining a healthy and sustainable digital ecology by formulating strategic policies, increasing investment in infrastructure, improving the regulatory system, and promoting the training of digital talents. In particular, the rise of smart home devices, wearable devices, industrial Internet of Things, and other fields has made the Internet of Things technology has been applied and promoted on a large scale [39-41]. Virtual and augmented reality technologies have also seen significant development during this period. VR devices such as Oculus Rift and HTC Vive, as well as AR devices such as Microsoft's HoloLens, have made these technologies widely used in gaming, education, healthcare, and other fields [42-44]. In 2016, China promulgated the Opinions on Deepening the Reform of the System and Mechanism for Talent Development, aiming at establishing a mechanism for collaborative innovation among experts in science, technology, and engineering, establishing a unified information management platform for talent engineering projects, and promoting the integration of talent engineering projects with various scientific research and base plans. The Federal Cybersecurity Workforce Strategy and the Cybersecurity National Action Plan address the growing need for cybersecurity professionals across the federal government and improve the recruitment, training, and retention of cybersecurity talent across federal agencies. The NSA has established 21 academic centers of excellence at universities to train students in advanced cyber practical techniques, with top talent retained in the intelligence community through internships; The US Cyber Scholarship Foundation set up the "Cyber Start America" program, which selects high school students with perseverance and curiosity across the country to participate in the annual cyber security simulation challenge, and those who perform well will receive scholarships to further their studies in computer science and cyber security.

The third stage is the jump period of digital talent research (2019-2022), and the research field is rapidly expanding. The number of relevant studies has increased significantly. The number of published papers will peak in 2022. This period accounted for 57.5% of the total number of publications. At this stage, the research mainly focuses on talent management

and training in artificial intelligence, big data, and digital transformation. The research direction has shifted from the promotion of digital technology to the training of digital talents and attempts to build a digital talent training system in some fields. To solve the shortage of talent in the digital economy industry and fill the gap between academia and industry, some scholars have established an interdisciplinary talent training innovation model that combines academic and industrial resources [45]. The COVID-19 pandemic has led to a further increase in the demand for digital talent, and attracting and retaining these experts is a huge challenge for governments, especially in small towns and municipalities, with academics presenting a global perspective on the need for ICT experts in the EU and Bulgaria in particular, based on the Talent Magnet project. Guidelines for developing and managing local talent attraction and retention programs have been developed [46]. We will strive to build a team of high-level digital talents with large scale, excellent quality, optimized structure, and reasonable distribution to support the high-quality development of the digital economy.

The fourth stage is the plateau period of digital talent research (2023-), although the number of publications in 2023 has declined, the overall attention and research volume is still high. Articles published in 2023 are more focused on digital talent development and management in the context of Industry 4.0. Because of the lack of digital capabilities in the workforce and limited awareness of digital talent, Industry 4.0 is a challenge for governments and businesses. Scientific research institutions should cooperate closely with enterprises to jointly carry out the cultivation, training, and management of digital talents, achieve the effective integration of academic theory and practical application, meet the rapidly changing market demand, and promote the development of the digital economy. Therefore, it is urgent to build a new model that emphasizes the development of employees' digital capabilities. Some scholars put forward a new maturity model (MM) based on employee competency development. Maturity models (MM) can help practitioners and researchers assess an organization's level of Industry 4.0 adoption to improve future operations. In addition, a roadmap is presented to guide workforce development, which considers the digital challenges employees face as they advance the adoption of Industry 4.0 strategies [47]. The supply and demand chain of information and communication technology (ICT) or digital talent and industrial demand in Malaysia has been unbalanced. The supply of graduate degrees and diplomas in ICT-related disciplines (such as computer science, multimedia, animation, information technology, etc.) still exceeds the demand of the ICT industry. Therefore, some scholars have proposed a process-based framework to bridge the gap between the demand and supply of ICT talents through the use of business intelligence technologies [48]. To empower digital talents for the development of enterprises, we should hold customized training courses in line with the needs of enterprises, cultivate a group of interdisciplinary talents who understand both the needs of enterprises and digital technologies, and contribute to the sustainable development of the digital economy.

4.2 Countries of Publication

Digital talents have become a hot topic in the global academic community, and the number of academic achievements in various countries reflects the research level in this field to a certain extent. The cooperation between countries not only reveals the characteristics and technological advantages of each country in digital talent research but also shows the overall research dynamics in the field. This section uses a knowledge graph and co-occurrence analysis to show the publishing situation of countries and their cooperation networks. Based on data from the countries of 703 authors, a total of 56 countries participated in the study of digital talent. This study focuses on countries with three or more published papers and maps a global knowledge map of country collaboration for digital talent research, as shown in Figure 3.

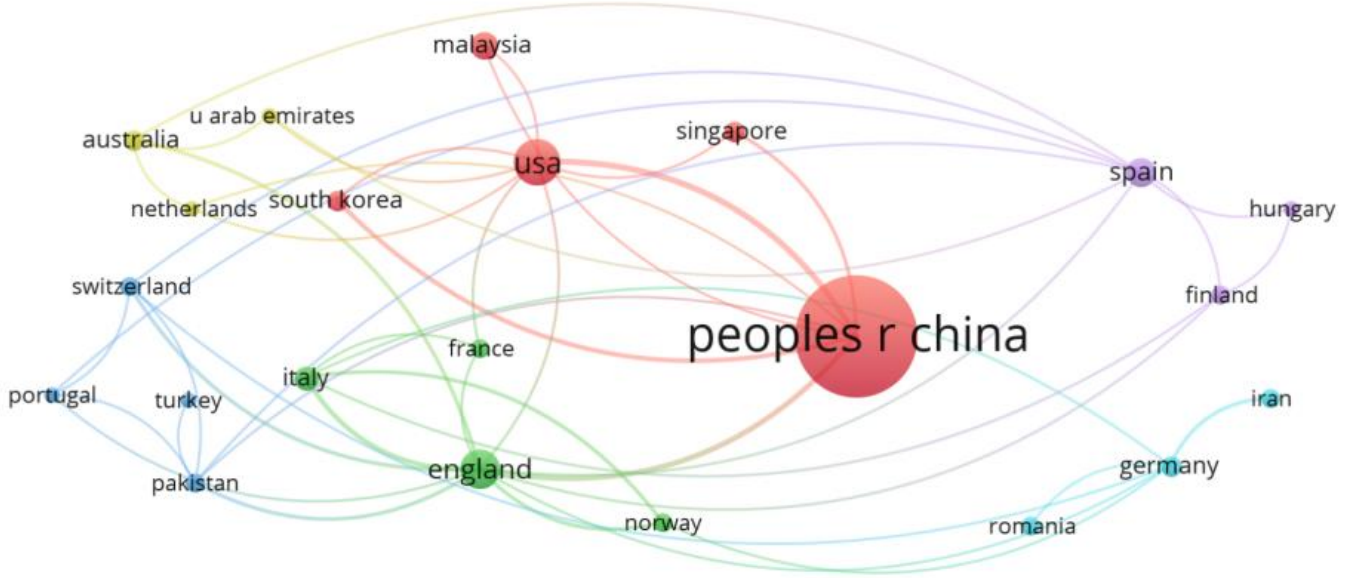

Figure 3: The countries of publication (national cooperative relationship).

The size of the circle represents the number of publications in each country, and the thicker the lines between the circles, the more collaborations between the two countries and the closer the partnership. As can be seen from Figure 3, the major publishing countries of digital talent research papers include China, the United States, the United Kingdom, India, and

Spain. Among them, academic cooperation between China, the United States, the United Kingdom, and South Korea is particularly frequent. The top 10 countries accounted for 70.15% of the global total, indicating that the majority of research in this field is concentrated in a few countries or regions. Most of these countries are economically developed and a few that are developing rapidly. These countries or regions are facing a strong demand for digital talents in the process of promoting the digital transformation of the economy. Therefore, we can speculate that the concept and research of digital talent are gradually rising and getting widespread attention with the wave of global digital transformation. The rapid development of digital technology has brought about profound changes in industry and society, and digital talent is an important resource to cope with this change, so relevant research has flourished and dominated in these countries.

In addition, to gain a clearer picture of the global development of digital talent, the study further sorted out and visualized the evolution of the top five countries with the highest number of published papers in chronological order. In the evolution diagram presented, the higher the color block height, the more documents issued by the corresponding country, as shown in Figure 4. As can be seen from Figure 4, the number of literature on digital talent in China has steadily increased over time, especially in 2022 and 2023, the number of published literature on digital talent in China has increased significantly. In 2022, China ranked first in the world in the number of documents issued. Other countries posted relatively few papers, and the data did not change significantly. Looking at the entire literature evolution chart, it can be seen that with the passage of time and the development of the national economy and technology, the amount of literature related to digital talent research is generally on the rise.

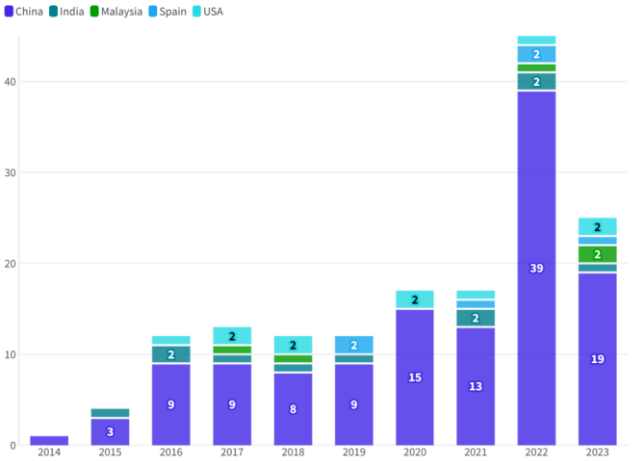

Figure 4: Evolution of literature volume by country.

4.3 Institutions of Publication

This section not only analyzes the publishing situation in each country but also shows the collaborative relationship between the publishing organizations through the knowledge graph. At the same time, the co-occurrence analysis method is used to deeply analyze the cooperation among publishing institutions. To ensure clarity and representativeness of the data, each paper partner was screened when obtaining the knowledge graph of different publications, institutions with more than two publications were included in the analysis, and the maximum threshold was set at 25 institutions. This highlights the relationships and influence of key partner institutions. Figure 5 shows the final synergy analysis results.

Figure 5: Knowledge map of organizations of publication.

As can be seen from Figure 5, most of the institutions publishing papers are mainly independent publications, and only a few institutions have cooperative relationships. It can be seen from the figure that only 5 groups of institutions show a co-occurrence relationship. One of the most collaborative articles was by SINTEF, University of London, Politecnico di Milano, and Monash University. SINTEF (Stiftelsen for industriell og teknisk forskning) is a multi-disciplinary contract independent research institute founded in Norway in 1950. The collaborators come from institutions in different countries, demonstrating the importance of international collaboration in bringing together the world's most advanced research resources and talents.

The largest number of published papers are mainly from universities in China and the United States. Tsinghua University is one of the top institutions of higher learning in China, with leading research and teaching achievements in computer science, artificial intelligence, big data, cybersecurity, and other fields, while maintaining close cooperation with many of the world's leading technology companies and research institutions. Through its advanced research facilities and high-quality educational resources, Tsinghua University has trained a large number of high-quality talents in the field of digital technology and occupies an important position in the global field of digital science and technology. Massachusetts Institute of Technology (MIT) is one of the world's top scientific and engineering research institutions, founded in 1861. He founded the Computer Science and Artificial Intelligence Laboratory (CSAIL), one of the world's leading computer science and artificial intelligence research institutions. CSAIL has made many breakthroughs in machine learning, natural language processing, computer vision, and other fields. MIT emphasizes interdisciplinary education and research, encouraging students to innovate and collaborate in multiple fields such as computer science, engineering, and data science. However, most institutions publish papers independently and do not form a collaborative group relationship.

The analysis of the above results shows that while many universities and research institutions are already conducting research in the field of digital talent, the progress of research in this field varies widely among countries. As a result, the cooperation between the research institutions of various countries is relatively loose and fails to form a close international collaboration network. This phenomenon shows that digital talent research is still in a relatively preliminary stage of theoretical exploration, and a highly integrated cooperation system has not yet been developed. In addition, this fragmented research model also reflects that universities and research institutions worldwide have not yet established a unified research platform or community in the field of digital talent. Institutions often work in isolation and lack systematic cooperation and knowledge sharing, which limits the rapid development of the field. To promote the in-depth development of digital talent research, it is necessary to strengthen cross-border and cross-institutional collaborative innovation, build a global research cooperation network, promote the two-way interaction between theory and practice, and jointly cope with the challenges of global digital transformation.

4.4 Journal of Publication

In this section, bibliometrics is used to collect and analyze published journal literature related to digital talents. To more intuitively show the time evolution of the data, an area stacking graph is used to show the annual publication trend of digital talent-related literature in different journals. The area stack chart can clearly show the contributions of each journal in different periods, which helps us intuitively understand the development dynamics of research hotspots. In this study, a total of 233 articles on digital talent were analyzed across 167 different journals. To highlight the key points, this section selects the top 10 journals in terms of the number of published papers, and plots their annual publication volume into an area stack graph, as shown in Figure 6.

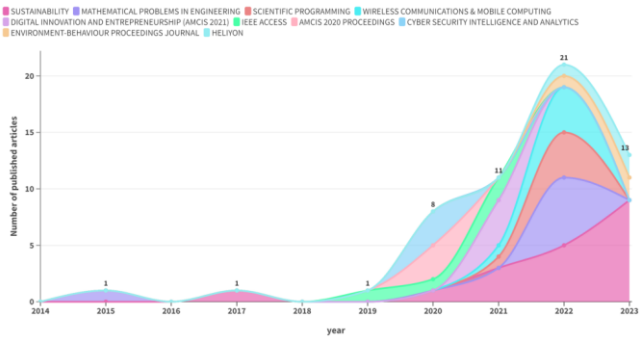

Figure 6: Area stacking diagram of annual publication volume of different journals.

In Figure 6, the horizontal axis shows the period from 2014 to 2023, and the vertical axis shows the number of publications. Different color areas represent different journals. The number of publications on digital talent has undergone significant changes across journals, with most journals showing a continuing upward trend. This shows that the research of digital talent is getting more and more attention over time. In addition, the distribution of digital talent-related papers covers a wide range of fields such as education, science, engineering, and telecommunications. This not only shows that digital talents involve an extremely wide range of knowledge areas, but also reflects the interdisciplinary nature of the field of study. This broad distribution and growth trend bodes well for a future in which more and more journals will focus on and publish research on digital talent. This trend shows that the study of digital talent is gradually becoming an important issue in multiple disciplines.

In addition, the citation frequency of a paper can accurately reflect the quality of the paper and the degree of recognition by other researchers. This section analyzes the citation frequency of journals with high publication volume, and the results are shown in Figure 7.

As can be seen from Figure 7, both open-source journals and non-open-source journals have shown a gradual increase in the number of citations, especially in recent years, which indicates that more and more researchers have begun to pay attention to the study of digital talent. Among them, the journal "INFORMATION PROCESSING & MANAGEMENT" with the most cumulative citations has a total of 147, and the open source journal "SUSTAINABILITY" with the most cumulative citations has a total of 110. The papers of De Mauro from Univ Roma Tor

Vergata and Univ Kent and Shamim from Kent Business Sch are highly cited, and the papers published by the above scholars are also of great significance to the development of digital talent research.

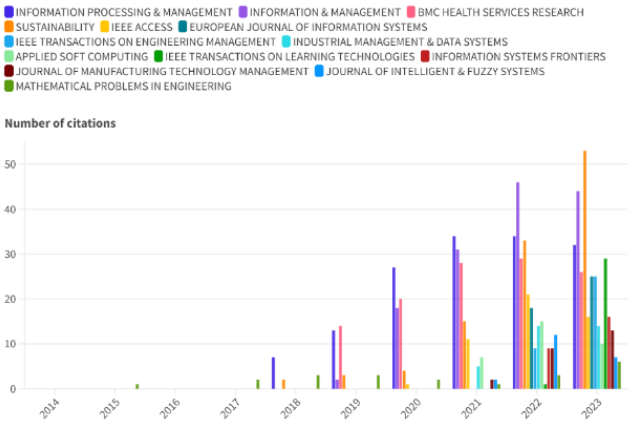

Figure 7: Changes in citation times in different journals.

4.5 Core Authors and Research Fields

Core authors play a key role in driving research and innovation in the field of digital talent, often leading related disciplines or research directions and forming an academic community with academic leaders at the core [49]. By using the knowledge graph method, this section presents the core authors and their cooperative networks and analyzes the cooperative relationships among the core authors and the collaboration in the research field by using the co-occurrence analysis method [50]. There were 703 authors in the 233 articles studied. To identify the core authors, the authors who published two or more articles were defined as the core authors, and 24 core authors were ultimately identified, accounting for 3.28% of the total authors. VOSviewer software was used to analyze the collaboration network of the 24 core authors in-depth, and the collaboration diagram of the core authors was generated (see Figure 8).

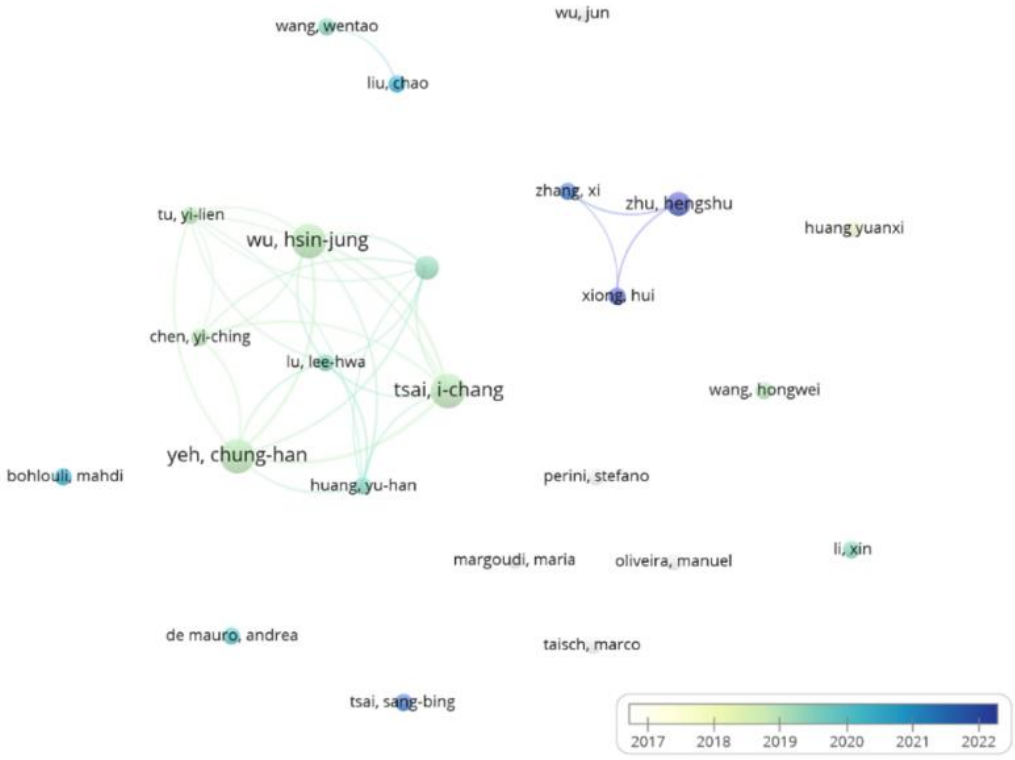

Figure 8: Core author collaboration association graph.

As can be seen from Figure 8, researchers of digital talent are still scattered in general. There are 11 people independently researching digital talent, and the number of two-person, three-person, and eight-person teams is 1. With the progress of digital transformation, the number of scholars entering the field of digital talent research is increasing, and the cooperation between scholars fluctuates greatly. With the deepening of research, there is an increasing trend of cooperation among scholars. Tsai, I-Chang, Wu, Hsin-Jung, Chen, yi-ching, Tu, yi-lien, and Yeh, Chung-Han have worked together in the field of computer science. In 2018, Tsai, I-Chang and Wu, Hsin-Jung proposed that digital talent resources are the key to economic growth and developed an innovative hybrid model of cross-field ICT talent training under the digital economy [51]. In 2019, the academic community with Tu, Yi-Lien as the core created a course learning map for cross-field digital talents, providing solutions for the training of cross-field digital talents [52]. In addition, an academic group with Chen, Yi-Ching as its core has established an interdisciplinary digital talent innovation management system (TMS) that combines academic and industrial resources, using blockchain technology to reduce management and recruitment costs and ensure the authenticity of resumes [53].

5. Research Hotspots and Trends of Digital Talents

Keywords play a key role in summarizing and summarizing the subject content in the research. By analyzing the keyword

co-occurrence density map, we can deeply understand the research hotspots and trends in a certain field, and provide a strong basis for future in-depth research. Adding the time dimension to the analysis can help reveal the co-occurrence of keywords in different periods, to identify the changes in the scope of research topics and the evolution trajectory of hot topics. This kind of analysis can not only show the dynamic development of the research field, but also reveal the possible research trends in the future, and provide an important reference for researchers to make research plans and directions.

5.1 Keyword Co-Occurrence Density Map Analysis

In this section, keyword density is shown through the knowledge graph method, and keyword co-occurrence analysis is carried out to identify the research hotspots in the field of digital talent. The study analyzed 233 kinds of literature and extracted 928 keywords. To ensure the validity of the analysis, the minimum threshold of keyword occurrence times is set to 3, and 76 keywords that meet the conditions are screened out. The VOSviewer was then used to generate a keyword co-occurrence density map (see Figure 9), which provides the intensity and density distribution of the relationship between the keywords. This analysis method not only helps to identify the research hotspots in the field, but also reveals the potential links between various keywords, and further clarifies the research trends and key directions in the field of digital talent.

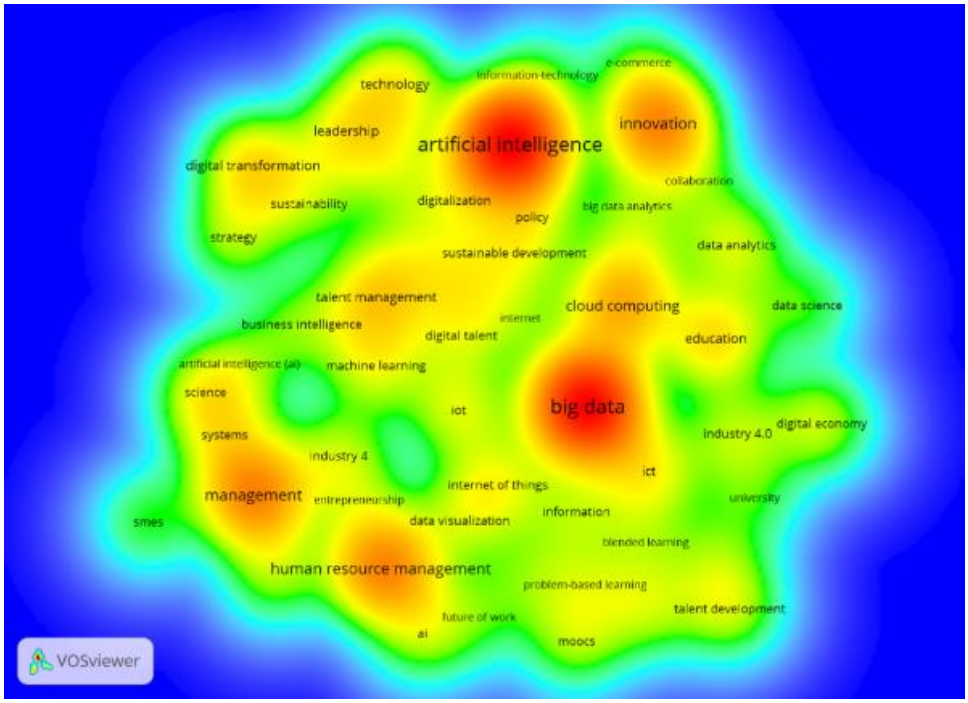

Figure 9: Keyword co-occurrence density map.

In Figure 9, the keyword co-occurrence density map shows the research hotspots and important directions in the field of digital talents through the gradient of colors. The color of each dot represents the density of keywords near that area, with red indicating dense keywords and blue indicating sparse keywords. There are three main color gradients: the red areas focus on the keywords “artificial intelligence” and “big data,” reflecting the central role of these technologies in driving digital transformation; The orange area covers keywords such as “human resource management”, “innovation”, “talent management” and “cloud computing”, showing the close combination of technology and management; The green areas focus on “talent development”, “Data Science”, “sustainable development” and “Industry 4.0”, reflecting the application of digitalization in a wider range of fields and its role in promoting sustainable development and industrial upgrading. This picture reveals the deep connection between technology and management, talent cultivation, and sustainable development in digital talent research.

By combining the research content, the author believes that the current academic research focus on digital talents can be divided into three themes. First of all, in the era of accelerated digital transformation, the training and development of digital talents have become a key factor in enhancing the competitiveness of various industries and enterprises, and the training of digital talents for the digital economy has become the current international trend. On the one hand, to improve the problem that employees with non-information technology-related backgrounds cannot become digital talents through self-study, artificial intelligence technology is used to identify the starting point, course level, learning path, and learning evaluation of learners, build a course learning system for cross-domain digital talents, and cultivate employees’ practical ability in artificial intelligence, big data, cloud computing, and other fields. Higher education through the integration of disciplines and curriculum system reform to accelerate to adapt to the industry 4.0 era of talent and technical ability needs. On the other hand, the market competition for digital talents is increasingly fierce, and the use of digital technology to achieve efficient talent screening has become the technical bottleneck of the current social supply and demand development. Recruitment information can be classified and managed through digital technology so that governments and enterprises can screen digital talents.

Second, the rapid development of big data and artificial intelligence technology is profoundly transforming the field

of talent management, bringing unprecedented opportunities for innovation in talent performance evaluation and employee training. Through accurate data collection and analysis, enterprises can collect employees' work data, social behavior data, project participation, etc., integrate and generate comprehensive employee performance reports, and help managers fully understand employees' work performance. In addition, by combining quantitative assessment and qualitative feedback, companies can provide a more comprehensive performance assessment. By using artificial intelligence technology to monitor employees' working status and performance in real time, enterprises can provide timely feedback and suggestions to help employees constantly improve and enhance. In terms of employee training, intelligent training needs analysis identifies skills gaps, determines training needs, and uses AI technology to recommend personalized learning paths and training courses. The online learning platform provides flexible and diverse training courses, and employees can arrange their own learning time. Big data technology tracks and evaluates the training effect in real-time, analyzes the learning progress and knowledge grasp of employees, and timely adjusts the training plan. With the continuous development of technology and the deepening of application, future talent management will be more intelligent and personalized, and the talent management level of enterprises will continue to improve.

Finally, the widespread adoption of Industry 4.0 and cloud computing technologies is not only driving changes in the manufacturing and IT industries but also significantly changing the skill requirements and career paths of digital talents. Industry 4.0 technologies, such as the Internet of Things, smart manufacturing, and the Industrial Internet, have created a surge in demand for digital talent with knowledge and application capabilities of these technologies in the manufacturing industry. Enterprises need professionals who can design, deploy, and maintain intelligent production lines and automation systems. In addition, the application of Industry 4.0 technologies also requires digital talent with data analysis and machine learning skills to achieve optimization and predictive maintenance of production processes. This change in skill demand has prompted digital talents to constantly update and upgrade their knowledge reserves to adapt to new trends in the development of the industry. Enterprises need talents with skills in cloud computing architecture design, cloud service deployment, and management, and data security to make full use of the advantages of cloud computing to achieve flexible resource allocation and efficient data processing. In addition, the growth of cloud computing technology has also created a demand for DevOps engineers and cloud security experts, driving a diversification of career paths for digital talent. The application of cloud computing technology allows digital talents to find career development opportunities in a wider range of fields, thus achieving career diversification and continuous progress.

5.2 Keyword Co-Occurrence Time Span Analysis

In this section, the evolution trend of keywords in different periods is shown through the knowledge graph method, and the research direction of the future digital talent field is deeply discussed with the co-occurrence analysis method. By introducing the time dimension into the keyword analysis, the dynamic development trajectory of this field can be revealed more clearly. In Figure 10, different colors represent the average year of occurrence for each keyword, with red indicating that keywords are relatively new and concentrated in the last few years, while blue represents earlier keywords. This color coding can not only directly reflect the temporal evolution of each keyword, but also reveal the basic concepts proposed earlier in the field of digital talent and the cutting-edge trend of current hot research. Through this method, it can accurately capture the temporal and spatial changes of research hotspots, and provide a scientific basis and strategic reference for the research direction of digital talents in the future.

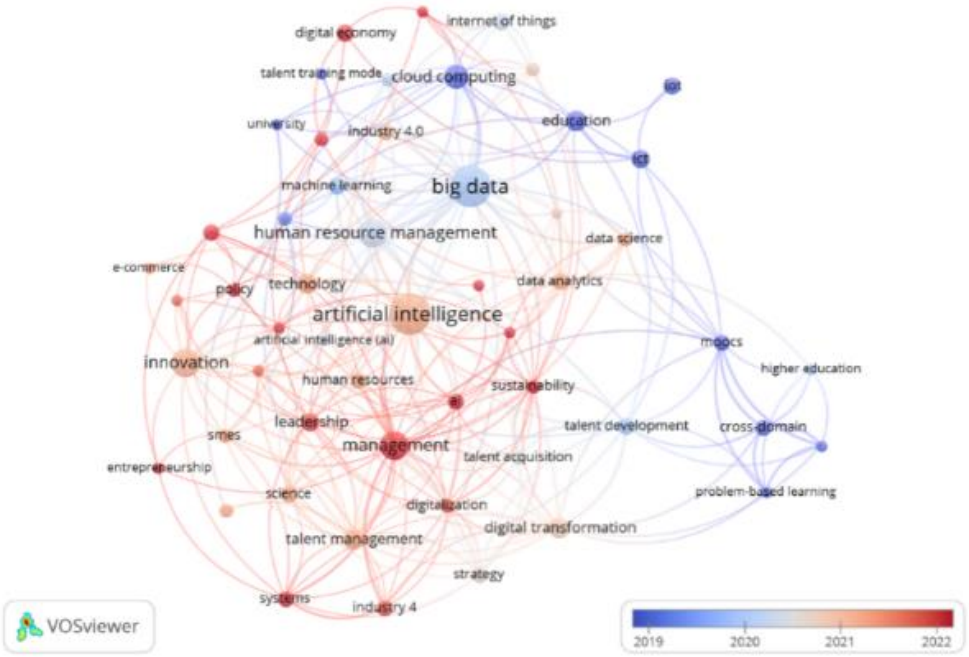

Figure 10: Keyword visualization knowledge map.

In Figure 10, the size of the circle in which the keyword is placed indicates the frequency with which the keyword appears. The more often it happens, the bigger the circle. The line between the circles represents the co-occurrence relationship between the two keywords, and the line width represents the frequency of the two keywords appearing simultaneously. The higher the frequency of simultaneous occurrences, the wider the line.

As can be seen from the figure, the three largest keywords in the circle are “artificial intelligence”, “big data” and “human resource management”. Therefore, keywords can be grouped into three clusters, as shown in Table 1. Based on the cluster and keyword knowledge graph, the research trend of digital talent is divided into three directions: first, the organic integration of intelligent technology and digital talent and innovation-driven talent training mode; Second, how the application of big data and data science technologies can drive intelligent management in digital talent recruitment, performance evaluation, and career development; Third, how to cultivate management talents with digital thinking and leadership in the process of digital transformation.

Table 5: Digital talent keyword cluster.

Keyword cluster	Keywords included in the cluster
Cluster A	Artificial intelligence, industry 4.0, innovation, information-tec hnology
Cluster B	Big data, cloud computing, ICT, internet of things, data science, machine learning,
Cluster C	Human resource management, leadership, business intelligence, talent management, digital talent

First of all, in the wave of rapid development of the digital economy, industry 4.0 based on Artificial intelligence has become the core force to promote change [54]. Industry 4.0 uses technologies such as the Internet of Things, big data, artificial intelligence, robotics, and cloud computing to realize intelligent, automated, and customized transformation of production, thereby improving efficiency, reducing costs, and improving product quality [55]. On the one hand, in the practice of intelligent technology, a large number of talents are needed in every link from technology research and development, application and opening up to delivery and operation. With the increasingly clear division of labor in the industrial chain, the ability needs of different positions tend to be detailed and diversified, which further intensifies the contradiction between the supply and demand of talent. On the other hand, intelligent technologies enhance human cognition through artificial intelligence, machine learning, and data analysis, enabling digital talents to solve complex problems and make more precise decisions. Cognitive enhancement not only improves individual efficiency but also promotes the sustainable development of the overall innovation capacity. With the assistance of smart technologies, digital talent can more effectively share knowledge, coordinate tasks, and solve problems, thereby improving the overall performance of the organization. Adaptive learning systems facilitate the continuous development of digital talent through personalized learning paths and real-time feedback. Intelligent technology not only provides a variety of learning resources but also dynamically adjusts the learning content and progress according to individual needs, ensuring that talent skills are synchronized with technological progress.

Second, In the digital economy, most companies around the world have made digitalization a key and important strategy. In the final analysis, digital transformation needs the protection of talent, teams, and organizations [56]. First, companies build profiles of candidates through big data analysis and use machine learning algorithms to automatically screen resumes, accurately matching job requirements with candidates’ skills and experience. This not only improves hiring efficiency and accuracy but also makes hiring decisions more data-driven. For example, by analyzing data from social media, career websites, and internal databases using natural language processing, companies can predict candidates’ performance potential and cultural fit, while optimizing hiring strategies through analysis of talent market trends. Second, companies can assess their performance and identify high-potential employees and training needs through real-time analysis of employees’ work data. Using predictive analytics models, companies can predict the career path and potential performance of employees and develop personalized career development plans. In addition, by analyzing employee interaction data and emotional expression on internal communication platforms, companies can monitor employee job satisfaction and mental health status, and timely intervene and adjust management strategies to improve employee experience and performance. Third, based on employees’ skills, interests, and performance data, companies can use recommendation system technology to provide personalized career development advice to help employees plan career paths and goals. Through data-driven learning and development initiatives, companies can design targeted training programs to upgrade the skills and competitiveness of their employees. At the same time, by using big data and machine learning models to predict brain drain, analyze the reasons for leaving, and take preventive measures, enterprises can effectively improve talent retention and ensure the long-term stability of key talent.

Finally, due to the uncertainty of the digital economic environment, the phenomenon of cross-industry cooperation mode has become a normal phenomenon, for an enterprise leader, having cross-border digital leadership and strategic thinking has become a basic ability. [57]. First, digital transformation requires managers to be able to collaborate and innovate across departments. By building an open innovation platform, enterprises can encourage collaboration and knowledge sharing across departments. For example, setting up innovation LABS or digital workshops to promote interaction and collaboration between different departments and stimulate innovative thinking and practice. At the same time, activities such as Hackathons (A Hackathon is a programming activity that takes place in a concentrated period, usually lasting from 24 hours to a few days.) and innovation competitions are held to encourage management talents to propose and implement innovative solutions and enhance their leadership and influence in digital transformation. Second, developing digital leadership needs to be practiced in real business scenarios. By setting up a digital transformation project team, companies can allow management talent to play a leadership role in the actual project and directly participate in the development and execution of digital strategy. This practice-driven approach not only improves their understanding of digital technologies but also enhances their decision-making and team management skills in a digital

environment. At the same time, through regular project evaluation and feedback, we help management talents to continuously optimize leadership strategies, improve leadership, and play the fundamental role of digital talents in supporting the digital economy.

6. Conclusion and Prospect

The sustainable and high-quality development of digital talent is of great significance for the wide application of digital technology in various sectors of society. However, the specific standards and programs for the training of digital talents are still being explored, and there are also differences in the training methods of digital talents in different countries and regions. From a global perspective, this paper makes an in-depth analysis of the research status of digital talents in various countries and fields. By showcasing four periods in the development of digital talent research over the past decade, key countries, institutions, and academic journals that play a key role in the development of digital talent are identified. It summarizes the current hot topics in digital talent research, including the need for technical skills training, interdisciplinary competence development, and lifelong learning, and explores the impact of future research trends such as artificial intelligence and automation on the demand for digital talent. In addition, this paper also pays special attention to the sustainable development of digital talents, emphasizing the long-term cultivation and development of digital talents through educational reform and industry cooperation.

This study is based on the literature about digital talent research in the Web of Science core database in the past decade and opens up a new frontier perspective for the field of digital talent training and development. The research is dedicated to exploring how to better cultivate and utilize digital talent to drive the digital transformation and sustainable development of society.

First, at the theoretical level, this study focuses on the definition of digital talent. In the context of the digital age, the definition of digital talent needs to break through the traditional narrow definition and is not limited to those with information and communication technology (ICT) professional skills. Digital talent should include individuals who can use diverse skills to drive innovation and development in a rapidly changing digital environment. This includes technologists with specialized skills such as data analysis, programming, and cybersecurity, but it should also include people who are digitally literate and able to use digital tools to collaborate across domains and solve complex problems. With the widespread application of emerging technologies such as artificial intelligence, Internet of Things, and blockchain, the definition of digital talent should be more flexible and multi-dimensional to reflect the growing demand for innovative thinking, adaptability, and continuous learning in digital transformation. Therefore, how to comprehensively define and train multi-level digital talents to adapt to the development of the digital economy is a key issue that needs to be solved in our current theoretical research and practice.

Second, at the practical application level, this study highlights the significant impact of digital talent on businesses and society. First, companies need to re-examine their talent recruitment and development strategies to attract and retain top digital talent. Customized training programs and career paths will help increase employee satisfaction and loyalty. Digital talent plays a key role in driving the digital transformation of enterprises by applying advanced technologies and innovative methods to optimize business processes, improve productivity, and facilitate the formation of new business models. Secondly, the development of digital talent is crucial to the overall digitization process of society. By cultivating people with high-level digital skills, the innovation and competitiveness of society as a whole can be significantly enhanced. For example, in the fields of smart city construction, digital medical care, intelligent manufacturing, etc., the innovation and application capabilities of digital talents directly determine the success or failure of projects.

In addition, this study pays special attention to the sustainable development of digital talent. To achieve the sustainable supply and development of digital talent, policymakers, and educational institutions need to establish sound education and training systems, encourage lifelong learning, and promote industry-university-research cooperation. Through policy support and resource investment, ensure that digital talents can constantly adapt to the changes of new technologies and the needs of the market, to lay a solid foundation for the long-term development of society. The cultivation and development of digital talents is not only a necessary measure to cope with the current technological change but also a key factor to achieve sustainable development of society. Through systematic research and practice, this study provides a new perspective and strong support for the efficient development of digital talent, and the findings will provide important references for enterprises, policymakers, and educational institutions to jointly promote the development of digital talent and ensure continued competitiveness and innovation in the rapidly changing scientific and technological environment of the future.

Finally, this study believes that the core goal of digital talent training is to promote the sustainable development of the digital economy and digital transformation and train high-quality talents to meet the needs of the digital age. Therefore, when training and utilizing digital talent, the multi-layered needs of enterprises and society must be fully considered. The application of digital technology should not only meet the current needs of the industry but also stimulate the innovative potential of digital talents and promote their personalized and diversified development. This requires companies, educational institutions, and policymakers to strategically focus on the introduction of digital technologies and explore new training models, rather than simply following the trend of technology or placing a one-sided emphasis on technology first. In the process of talent training, attention should be paid to improving the strategic thinking and innovation ability of digital talents, forming interdisciplinary knowledge structure and problem-solving ability. Digital technology should be combined with multi-field knowledge such as management, economics, and even sociology to deeply understand and grasp the resulting industrial structure transformation. At the same time, digital talent not only needs to possess a high level of technical

competence but also must possess high-level thinking skills and interdisciplinary vision to navigate complex business environments and drive innovation. Therefore, in the content design of digital talent training, it is not only necessary to cultivate their ability to use technical tools but also to emphasize their comprehensive literacy in strategy making, business decision-making, and innovation promotion. Only in this way can digital talents truly make long-term contributions to the digital economy and promote industrial upgrading and social progress.

This study only analyzed the results related to digital talents based on the Web of Science database and did not include relevant studies in other databases, which is a limitation of this study. Future research will further expand the data source to include more databases to ensure a more comprehensive and in-depth analysis of the current situation and the significance of digital talent development.

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Conflicts of Interest

The authors declare no conflict of interest.

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Author Profile

Jianxin Wu male, born in 1985 in Wuwei, Gansu Province, China,holds a Ph.D. in Management from Renmin University of China. He is currently a professor and master's supervisor at the School of Education, Shaanxi University of Science and Technology. Dr. Wu serves as a council member of the Institutional Strategic Planning Professional Committee of the National Association of Information Resources Research in Higher Education and a researcher at the Shaanxi Provincial Degree and Graduate Education Center. In 2018, he was selected for the "High-Level Doctoral Talent" program at Shaanxi University of Science and Technology, and in 2020, he was included in the Youth Program of the Shaanxi Province High-Level Talent Introduction "Thousand Talents Plan." He also serves as a youth editorial board member for core journals such as University Education Management, Academic Degrees & Graduate Education, and Chongqing Higher Education Research, and as a reviewer for multiple CSSCI journals (including the extended edition) in the field of higher education. Dr. Wu has published 56 academic papers in journals such as Higher Education Research, China Higher Education Research, and China Educational Technology. Several of his articles have been reprinted by Xinhua Digest, Renmin University Reprints (Higher Education), and the Chinese Social Sciences Network. He has authored two academic monographs published by national first-class publishers, co-authored two academic monographs, and presided over nine projects, including those funded by the National Social Science Foundation, Shaanxi Social Science Foundation, and Shaanxi Education Science Planning Projects.

Liyao Renfemale, born in 2001 in Xianyang City, Shaanxi Province, China, is currently studying for a master's degree in College of Culture and Education, Shaanxi University of Science and Technology, China. His research direction is educational informatization.

Yi Wang Organization: Yuwei Consulting (Shenzhen) Co., LTD.