An Analysis of the Current Status, Research Hotspots, and Trends in China's Vocational Education Against the Background of Artificial Intelligence

Jiahao Liu[1], Shuguang He[1*], Zhiliang Gao[1], Jiadi Wu[1], Weipeng Zhu[2]

[1]Changsha Preschool Education College, Changsha 410000, China
[2]Changsha Zhongjia School, Changsha 410000, China

*ljhccnu@126.com

Abstract. As the core driving force spearheading the new wave of technological transformation, artificial intelligence is profoundly reshaping the ecosystem and development trajectory of vocational education. To systematically grasp the research landscape in China's intersection of AI and vocational education, this study conducted a quantitative analysis of 474 relevant papers using the CNKI database and CiteSpace visualization tools.Findings reveal that research in this field has progressed through three distinct phases: an embryonic stage (2007–2016), a developmental stage (2017–2022), and an explosive growth stage (2023–present), with publication volume exhibiting an accelerating growth trend.Research power centers around vocational institutions like Tianjin University of Technology and Education and Changzhou Vocational College of Information Technology, alongside key undergraduate universities such as Tianjin University and Beijing Normal University. Research content focuses on the intelligent reform of vocational education teaching elements, the transformation of intelligent education ecosystems and systems, and the reconstruction of vocational competencies. This can be categorized into ten sub-research directions, gradually evolving into research hotspots such as talent cultivation, industry-education integration, smart education, and digital literacy.Research frontiers are shifting from macro-level big data and development pathways to micro-level professional development and curriculum systems, with emerging focuses on human-machine collaboration, smart dual-teacher models, curriculum-based ideological education, visualization, and digitization. Future efforts should strengthen academic community building and deepen the return to the essence of education, aiming to provide theoretical support and practical guidance for constructing a new ecosystem of vocational education in the intelligent era.

Keywords: Artificial Intelligence, Vocational Education, Research Hotspots, Literature Review, CiteSpace.

A. Y. M. A. Islam et al. (eds.), *Proceedings of the 2025 International Conference on Educational Technology and Management Information Systems (ETMIS 2025)*, Advances in Computer Science Research 129,
https://doi.org/10.2991/978-94-6239-630-2_40

1 Introduction

In recent years, artificial intelligence (AI) and its related technologies have undergone rapid transformation. Generative Artificial Intelligence (GenAI), exemplified by ChatGPT, is flourishing and gradually integrating into industries worldwide. In the foreseeable future, it will significantly boost socioeconomic development and may even reshape the landscape of national competitiveness. AI technology represents the next major technological revolution following steam power, electricity, and information technology—often termed the Fourth Industrial Revolution or Fourth Technological Transformation. Many nations have prioritized AI development as a national strategy. For instance, the United States has released reports such as “Preparing for the Future of Artificial Intelligence” and the “National Artificial Intelligence Research and Development Strategic Plan”. Concurrently, China places significant strategic emphasis on AI development, with numerous guiding and implementing policy documents issued at national, provincial, and municipal levels. On July 10, 2023, seven government departments including the Cyberspace Administration of China jointly released the Interim Measures for the Administration of Generative Artificial Intelligence Services, charting a course for the healthy development of generative AI. Yet what relationship exists between AI learning and human learning? How does AI impact education? How does AI reshape human learning methods? These are questions worthy of consideration by education practitioners. The education system is a complex dynamic system, with its dynamism reflected in the evolving interplay of its constituent elements—including learners, educators, learning environments, resources, and content. Vocational education, characterized as technical and skill-based learning, bridges industry needs with the educational framework, holding a unique position and mission. Its foundation is currently transitioning from industrialization to intelligentization [1].

A literature review of the China National Knowledge Infrastructure (CNKI) database reveals that while cross-disciplinary research on "AI + Vocational Education" has reached a considerable scale, most studies focus on conceptual clarification, definition of core elements, and current application status. Comparative analyses of developmental trends remain scarce. Therefore, this paper proposes to employ scientific knowledge graph methodology to conduct a visual study of China's “AI + Vocational Education” development landscape. This research holds value in both theoretical and practical dimensions. By analyzing existing literature data to identify research hotspots in China's “AI + Vocational Education” field, it can uncover potential developmental trends. Furthermore, exploring vocational education research progress from the novel perspective of interdisciplinary convergence offers advantages over traditional theoretical summaries, including quantifiability, deducibility, and visualizability.The specific contributions are as follows.

Contribution 1. Three developmental stages of China's “AI+ vocational education” research have been outlined.

Contribution 2. Identified core research strengths and structural characteristics.

Contribution 3. Identified three highly cited themes and ten sub-research directions.

Contribution 4. Predicted future research frontiers and development trends.

2 Data Sources and Methods

2.1 Data Sources

To ensure the comprehensiveness and scientific rigor of the dataset sources, this study utilized the “Specialized Search” function of the CNKI Chinese Academic Journal Database to obtain the required data resources.The formula is: “KY = Artificial Intelligence + Generative Artificial Intelligence + AIGC AND KY = Vocational Education + Higher Vocational Education + Higher Vocational Colleges + Vocational Institutions”. Analysis revealed that as of December 2024, there were 483 articles simultaneously using “Vocational Education” and “Artificial Intelligence” as keywords (KY) and indexed in the CNKI Chinese Academic Journal Database.After deduplication and data cleansing—removing conference notices, editorials, and other non-relevant content—a robust and unique dataset comprising 474 bibliographic records was obtained. Finally, data conversion generated a CiteSpace-compatible dataset.

2.2 Research Methods

CiteSpace is a knowledge graph analysis tool designed based on theories such as Kuhn's scientific development model, and structural holes in social network analysis. It possesses functions for interpreting the current state of a field and predicting its future prospects[2]. Developed by Professor Chaomei Chen at Drexel University in the United States, the software enables data mining and visualization of a specific research domain. To better map the development trends of vocational education research in China within the context of artificial intelligence,this paper introduces a quantitative research method of co-word clustering. Based on CiteSpace’s visualization analysis of the field knowledge map, it organizes explicit data such as publication status, authors and scientific communities, and research institutions within the field. By utilizing keyword co-word clustering to identify sub-research areas and provide detailed commentary, it deeply excavates and visually presents the current state, research hotspots, and trends in China’s vocational education research within the field of artificial intelligence. This provides convenience, guidance, and support for subsequent research endeavors.The specific research process of this study is shown in Figure 1.

3 The Current State of Research on Vocational Education in China from the Perspective of Artificial Intelligence

3.1 Analysis of Annual and Cumulative Document Output

The volume of publications exhibits an accelerating growth trend over time, with the trendline effectively explaining variations in the actual data. This index model

demonstrates high adaptability in revealing the growth patterns of publication volume. Based on real-world data statistics, supplemented by literature reviews and policy research, the interdisciplinary study of artificial intelligence and vocational education has been identified as progressing through three distinct research phases. Specific statistical findings are presented in Figure 2.

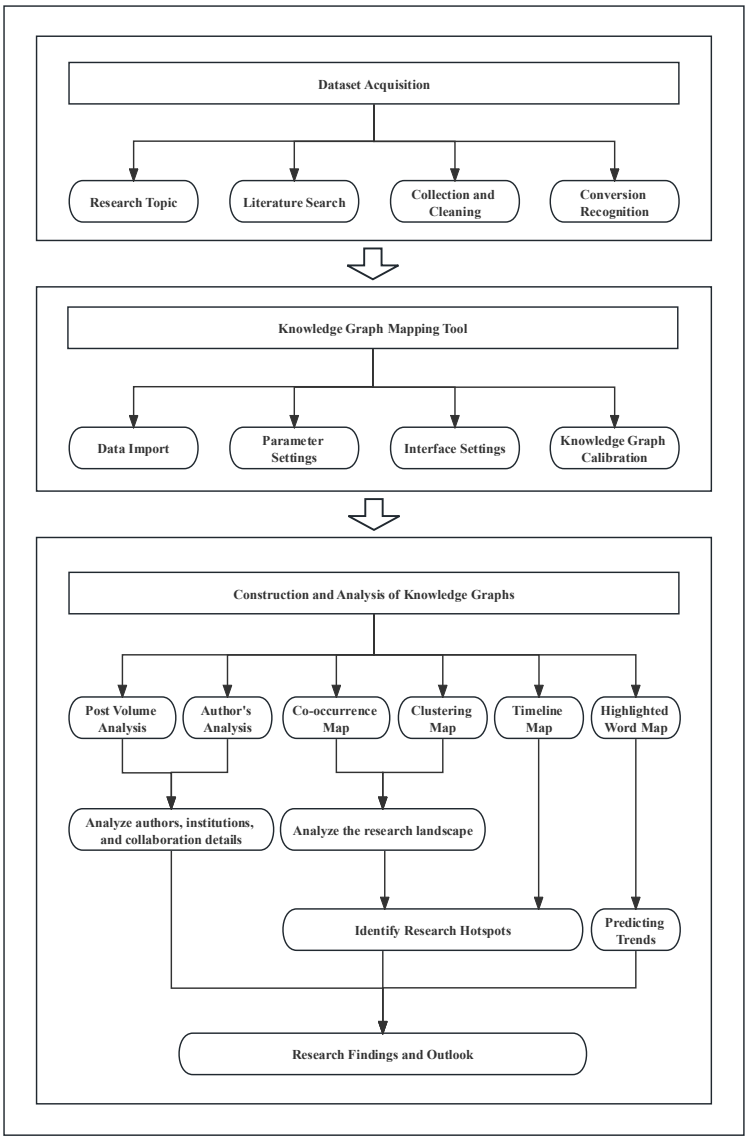

Fig. 1. Research Flowchart

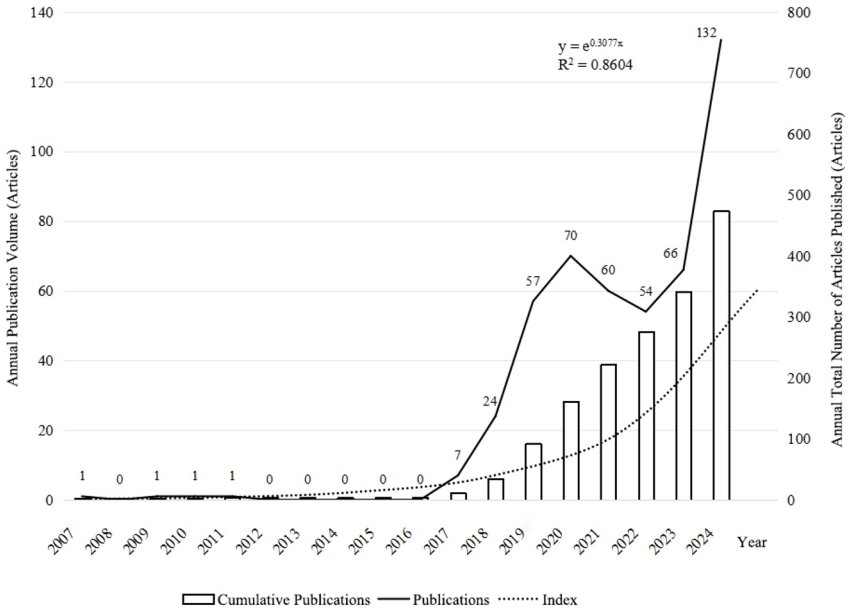

Fig. 2. Visualized Statistics of Annual Publication Volume and Cumulative Publication Volume

The first phase was the embryonic stage (2007–2016). The earliest core article in this research field appeared in 2007, authored by Chen Zhibin from Guangdong Polytechnic Normal University and published in Vocational Education. However, from then until 2016, research remained sparse with only three additional articles published. This indicates the stage was still in its infancy, characterized by immature research subjects, content, and paradigms. Individual researchers, driven by their own research acumen and interests, conducted preliminary explorations into the relationship between AI and vocational education from a practical problem-solving perspective.

The period from 2017 to 2022 constitutes the second phase of the study, namely the development stage. During these six years, a substantial volume of research literature emerged, with the number of publications showing an increasing trend over time until stabilizing within the range of 50-60 papers per year.The line chart shows that publication volume began climbing from 2017, with a steeper incline observed between 2018 and 2019, indicating a more vigorous publishing momentum.The plan explicitly states that “deep integration of AI with education is a key priority”. Thus, the introduction of these state-mandated policies has powerfully stimulated and propelled research in AI+education.

The period from 2023 to the present constitutes the third phase of research, namely the explosive growth phase. During this period, a substantial number of articles emerged, totaling 198, representing a leapfrog increase compared to the previous phase. Analysis reveals that this explosive growth can be interpreted from three per-

spectives: policy guidance, technological breakthroughs, and positive responses from the academic ecosystem. First, robust national policy and strategic initiatives have provided strong impetus. Second, the application scenarios of generative AI in education are gradually maturing, particularly through the use of generative AI tools like ChatGPT and Deepseek to assist teachers in course design.Third, the synergistic response from the academic ecosystem and the research focus on AIED. In 2024, global AI education research experienced explosive growth. Chinese scholars have closely followed international AI research frontiers while conducting explorations tailored to the unique characteristics of China's vocational education system.

3.2 Research Institutions and Collaborative Network Analysis

Analyzing research institutions and collaborative networks enables effective identification of the distribution of research capabilities and the composition of research groups within a specific research theme, clarifying the state of research and actual contributions.This study utilized bibliographic data from 474 publications as its source. Citespace network nodes were defined as “Institution” , employing the G-index algorithm with Pathfinder and Pruning sliced networks selected to generate an optimized pruned network. The results are shown in Figure 3. The network map contains 201 nodes and 58 edges, with a network density of 0.0029. Overall, collaborative ties among Chinese institutions engaged in vocational education and AI research remain loose, failing to form a cohesive scientific community. Locally, limited academic exchanges (occurring twice or more) exist between certain institutions:The School of Education at Tianjin University and the National Institute of Vocational Education at Beijing Normal University maintain cooperative ties; the Beijing Academy of Educational Sciences and Beijing Polytechnic College have established collaborative relationships; Tianjin University and Tianjin University of Technology and Education also sha re cooperative connections. In this study, Tianjin University of Technology and Education, Changzhou Information Technology College, Tianjin University, Nanjing University of Technology and Education, Sichuan Normal University, East China Normal University, and Beijing Normal University rank as the top six research institutions. Among these, Tianjin University of Technology and Education, Changzhou Information Technology College, and Tianjin University each published 6 papers, while the remaining institutions published 5 papers.

High-output institutions were categorized by type into three tiers: key undergraduate institutions, local undergraduate institutions, and vocational colleges. Statistics reveal that eight key undergraduate institutions collectively published 28 papers, twelve local undergraduate institutions published 37 papers, and twenty-one vocational colleges published 55 papers.Three key insights emerge from the classification statistics of research institutions: First, among institutions at all levels, the primary focus on the interdisciplinary field of “AI + Vocational Education” is concentrated in higher education institutions, while other research entities (such as companies and research institutes) show minimal engagement in this area. Second, within this research domain, vocational and technical colleges account for a relatively high proportion of total publications among high-output institutions, with a large number of par-

ticipating institutions.This indicates that vocational institutions bear significant responsibility in vocational education research, serving as the main force in this field. Representative institutions include Changzhou Vocational College of Information Technology (6 papers) and Fuzhou Vocational College (4 papers).Even among local undergraduate institutions, vocational universities demonstrate particularly outstanding research output. Tianjin University of Technology and Education (6 papers) ranks highest among all statistical institutions, while Nanjing Institute of Technology (5 papers) holds second place in this category.Thirdly, key undergraduate institutions demonstrate higher publication quality. While vocational colleges exhibit substantial publication volume, undergraduate institutions remain central among all institutions, particularly key undergraduate institutions represented by “Double First-Class” universities, which play a leading role.A detailed analysis reveals that among the publications from the eight key undergraduate institutions tracked in this study, most appeared in core journals with high citation counts. This indicates that Double First-Class universities like Tianjin University and Beijing Normal University have led the way in vocational education research by establishing theoretical paradigms and demonstrating practical research approaches.Among these, institutions such as the Faculty of Education at Beijing Normal University (National Institute of Vocational Education), the School of Education at Tianjin University, and the Institute of Vocational and Adult Education at East China Normal University have published core journal articles in this research field that have been cited nearly 500 times. These can be regarded as core research institutions and deserve close attention.

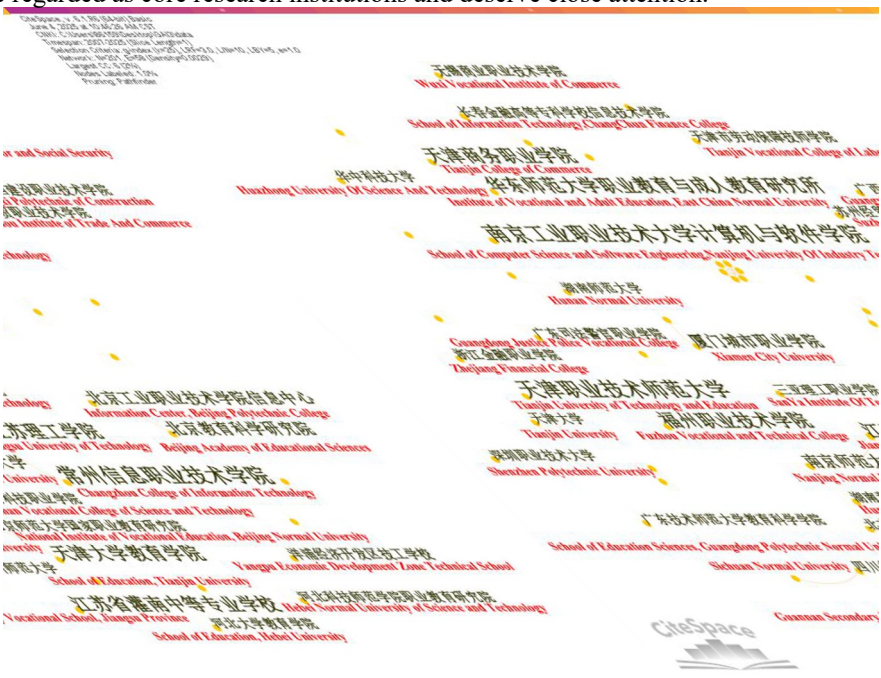

Fig. 3. Institutional Map of Vocational Education Research in the Context of Artificial Intelligence in China

4 Analysis of the Evolution of Research Hotspots in Vocational Education under the Lens of Artificial Intelligence

4.1 Keyword Analysis

Keywords encapsulate the research theme of a document and embody the core arguments of an article. The frequency of a particular keyword's occurrence corresponds to the number of documents associated with that keyword[3].Thus, by statistically analyzing keyword frequencies, one can gain an initial understanding of the research landscape within a discipline. To visualize the results more scientifically and intuitively, the obtained data was transferred into Citespace visualization, yielding a keyword co-occurrence map (Figure 4). The map contains 349 nodes and 459 edges, with a Modularity Q value of 0.8382 and a Mean Silhouette S value of 0.9883.Modularity Q and Mean Silhouette S represent the clustering modularity and average silhouette coefficient of knowledge graphs, respectively, serving as crucial parameters for evaluating graph framework characteristics. Generally, a clustering modularity (Q-value) ≥ 0.3 indicates a significant clustering structure; an average silhouette coefficient (S-value) ≥ 0.5 suggests reasonable clustering, while $S \geq 0.7$ signifies convincing clustering results[4].The co-occurrence maps obtained in this study meet the parameter requirements, exhibit good visualization results, and are convincing. Within the maps, node size corresponds to keyword frequency, while node color is arranged in concentric rings by year, representing the first to most recent appearance of the keyword from the center outward.Careful examination of the co-occurrence maps yields the following conclusions: First, keywords with high centrality are concentrated after 2019. This indicates that China's vocational education research under the AI paradigm gradually entered a mature phase after 2019. Articles published post-2019 garnered greater attention from relevant researchers, progressively becoming core literature within the field—a finding consistent with the earlier analysis of publication volume.Second, beyond core keywords serving as search terms, high-frequency keywords like “talent cultivation”, “industry-education integration”, “school-enterprise cooperation”, “big data”, “smart education”, and “teachers” exhibit high centrality. This indicates that with the advent of the AI era, researchers are increasingly interested in areas such as “talent cultivation”, “school-enterprise cooperation and industry-education integration”,“smart education” and “teacher development” within vocational education, which may emerge as new research hotspots.Third, the orange nodes with high centrality representing the latest research focus on “teaching strategies” and “curriculum-based ideological and political education”.This indicates that multiple researchers simultaneously explored “teaching strategies for vocational education in the context of artificial intelligence” and “curriculum-based ideological and political education in vocational education with artificial intelligence” in 2024. Subsequent researchers may wish to prioritize these areas, as they are likely to develop into new research frontiers.

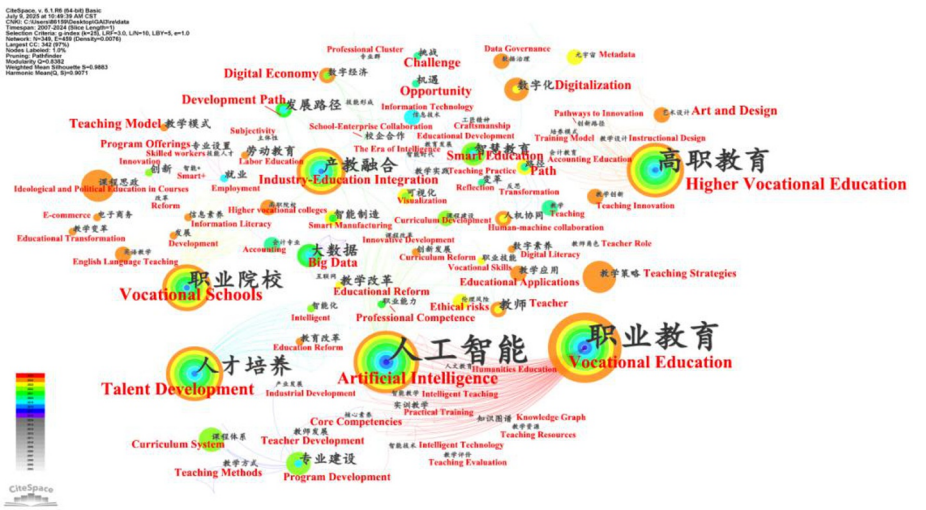

Fig. 4. Co-occurrence Knowledge Map of High-Frequency Keywords in Vocational Education Research within China's Artificial Intelligence Context

4.2 Cluster Analysis and Research Topic Summarization

Cluster analysis is an analytical method that groups data samples based on the similarity or dissimilarity of their features, aiming to maximize similarity within groups and minimize similarity between groups[5]. As an unsupervised learning method, cluster analysis can group datasets without predefined categories, revealing the latent value within the data.

This study employed Citespace for cluster analysis, utilizing the LLR algorithm with a time slice of one year and setting Pruning to Pathfinder and Pruning sliced networks to obtain the most suitable simplified graph. This yielded the cluster map of vocational education research within China's artificial intelligence landscape, as shown in Figure 5. The Q-value (Modularity Q) of this cluster map is 0.8341, and the S-value (Mean Silhouette) is 0.9891. Research indicates that clustering results are considered convincing when the Q-value exceeds 0.3 and the S-value reaches 0.7 [2]. Therefore, this cluster map exhibits a robust structure and delivers convincing results.The cluster map reveals that research on vocational education within China's artificial intelligence context can be grouped into 13 sub-research clusters. Within the same cluster, keywords with higher centrality rank higher and play a more critical role.After detailed review of the literature data within each sub-cluster, it was found that some clusters exhibit overlapping research themes with limited distinctiveness, allowing for appropriate consolidation. Additionally, Cluster 12 (Applied Undergraduate Programs) contains only two articles, insufficient to establish it as a new sub-domain within existing research. In summary, based on keyword centrality and specific semantics, the research clusters under the theme “Vocational Education in the Context of Artificial Intelligence” were named as shown in Table 1.

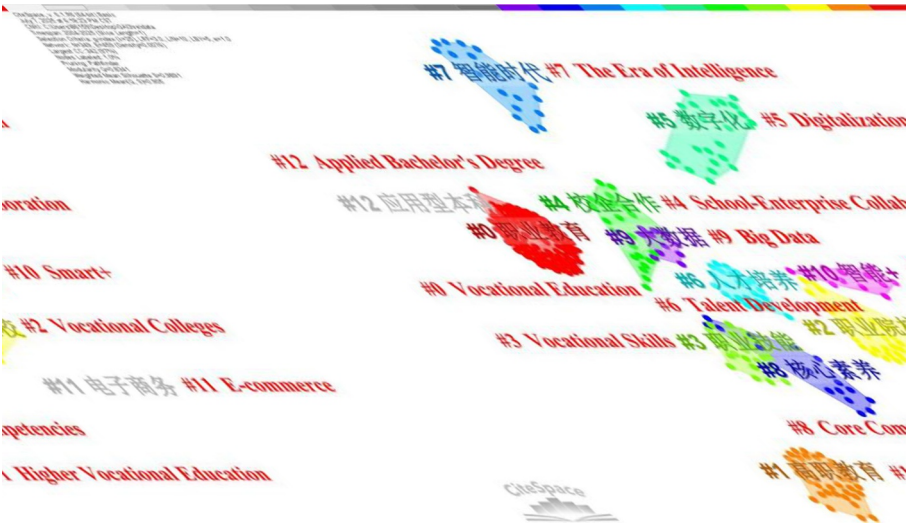

Fig. 5. Cluster Map of Vocational Education Research in the Context of Artificial Intelligence in China

Table 1. Research Themes in Vocational Education within the Context of Artificial Intelligence in China

Research Groups	Research Topic
1	Research on Talent Cultivation in Vocational Colleges in the Context of Artificial Intelligence
2	Research on Pathways for Industry-Education Integration and School-Enterprise Collaboration in the Context of AI
3	Research on Digital Transformation in Vocational Education in the Context of AI
4	Research on Visual Teaching Methods for Vocational Skills
5	Research on Technology-Enabled Empowerment in Vocational Education in the Context of AI
6	Research on Professional Competencies and Core Competencies in the Context of AI
7	Research on the Transformation of Vocational Education Teaching Models in the Context of AI
8	Research on the Transformation of Vocational Education Teachers' Competencies in the Context of AI
9	Employment Research in Vocational Education in the Context of AI
10	Research on AI Ethics and Societal Impact

4.3 Time Zone Maps and Research Hotspots Exploration

The temporal network map, also known as the “thematic path evolution diagram”, enables researchers to grasp the overall research trajectory while exploring hotspots across different stages from a temporal perspective. The temporal network map for this study, compiled through such analysis, is shown in Figure 6. Within the map, keywords are displayed according to their centrality—higher centrality is represented by more pronounced ultraviolet rings, indicating greater prominence in the research landscape.First, from a holistic perspective, research nodes with high centrality are concentrated in three periods: 2007–2016, 2017–2022, and 2023 to present. This aligns with the findings from the earlier “publication volume” analysis, corresponding to the “infancy”, “development”, and “explosion” phases of China's vocational education research within the AI landscape.The initial phase (2007–2016) saw research in its infancy, with only four articles published. While some researchers with heightened scientific sensitivity began to explore this field, the volume was insufficient to support the differentiation of distinct research themes. Articles during this period focused on AI curriculum reform in higher vocational education, the significance of implementing AI education, research on adaptive learning systems, and potential research directions for AI and vocational education in early studies.

The second phase was the development period (2017–2022). With breakthroughs in artificial intelligence technology, an increasing number of researchers began to recognize the application of AI in vocational education.During this period, multiple core keywords with high centrality emerged, signaling that research was gradually entering a mature phase. The research trajectory evolved from the early focus on the relationship between “vocational education and artificial intelligence” to multiple directions within the AI context, such as “talent cultivation”,“intelligent manufacturing”, “industry-education integration,” “school-enterprise cooperation”, “smart education”, “vocational competency development”, and “digital literacy”.Specifically, three research hotspots emerged during this phase, forming sub-directions within AI-driven vocational education. First, talent cultivation in vocational education. As the core mission of vocational institutions, developing professionals suited to contemporary societal needs remains a central research topic. With AI's exponential advancement, most industries will inevitably transition from labor-intensive to technology-intensive models, with many mechanical and repetitive roles gradually replaced by AI.Research on “vocational education talent development in the AI context” first emerged in 2017. For instance, Chen Ang (2017) focused on AI's impact on vocational talent, its effects on employment, and the resulting demands on vocational education [6].This category of research recognized early on the impact of AI development on employment and proposed new requirements for industry development and talent cultivation. Specifically, it emphasized the need to cultivate skilled professionals with high cultural literacy, strong comprehensive abilities, and excellent professional ethics to avoid being ruthlessly eliminated in the wave of AI advancement.

Fig. 6. Temporal Map of Vocational Education Research in the Context of Artificial Intelligence in China

Second, the integration of vocational education with industry and school-enterprise cooperation. Vocational education and industrial development form an inseparable whole, continuously interacting and integrating to create a vocational education ecosystem.Yang Jin et al. (2020)[7] emphasized that deepening industry-education integration is the key to enhancing the quality of vocational talent cultivation. Consequently, research on this integration has become a hot topic in the intersection of AI and vocational education, with numerous scholars proposing perspectives on its development amid AI disruption. The advent of AI has further liberated productivity, driving rapid internal transformation and development across industries, thereby raising talent requirements to new heights.Wang Yufei et al. (2022)[8] propose that AI-industry integration requires enhanced utilization of AI and related technological solutions to strengthen collaboration between vocational schools and local enterprises, thereby better addressing AI's impact.

Third, smart education and the digital transformation of vocational education. Discussing AI in education inherently involves educational informatization, with smart education regarded as its advanced form[9].Smart education constitutes a novel educational ecosystem characterized by ubiquity, perception, integration, and intelligence, built upon next-generation information technologies such as mobile internet, IoT, and big data [10]. In the AI era, vocational education must inevitably undergo informatization transformation toward smart education. Domestic research exploring the integration of vocational education with smart education transformation has intensified since 2018.For instance, Huang Liwen et al. (2020) proposed that human-machine coupled education represents the future direction for vocational education transformation. Achieving this requires intelligent creation of micro-teaching scenarios, such as smart classrooms, intelligent teaching resource repositories, and smart learning factories[11].Articles within this research cluster predominantly comprise highly theoretical

review papers. Though limited in number, their recent publication dates and high quality provide directional guidance for vocational education informatization under AI.

The third phase represents the explosive growth period (2023 to present), during which China's AI vocational education research has experienced rapid development driven by both technological innovation and policy guidance. Key terms such as “human-machine collaboration”, “smart dual-instructor system”, and “ideological and political education in curriculum” have emerged as central themes and research hotspots in this phase.First, breakthroughs in generative AI like ChatGPT and Deepseek have propelled vocational education from “tool-assisted” to “ecosystem-reshaping” transformation.Research has centered on human-machine collaborative teaching paradigms, exploring AI applications in personalized learning path design, intelligent assessment and feedback, and virtual training environment construction. For instance, Xu Guoqing et al. (2023) examined the impact of ChatGPT/generative AI on future vocational education from perspectives including occupational competencies, talent cultivation in vocational education, and research capabilities of vocational institutions[12]. Second, research on transforming smart dual-teacher teaching models emphasizes deep collaboration between AI and human educators. Yang Jianmei et al. (2024) employed a systems theory approach to construct an AI dual-teacher smart teaching model. Through questionnaire surveys and semi-structured interviews, they validated the model's positive impact on students' knowledge acquisition, skill enhancement, and competency development[13].Third, research on ideological and political education within vocational education curricula under AI contexts. This direction focuses on the deep integration of AI technology and ideological and political education within professional courses, aiming to advance vocational education's trinity of educational objectives: value shaping, knowledge transmission, and competency cultivation.For instance, Yin Li et al. (2024) argued that the technological rationality brought by AI development weakens human subjectivity. They proposed that ideological and political education in vocational education during the digital era should stimulate subject consciousness, cultivate social responsibility, and care for holistic human development[14]. Research on ideological and political education in the context of AI emphasizes the organic integration of value guidance and professional education, relying on AI to achieve precision and personalization in ideological and political education.

4.4 Analysis of Prominent Terms and Research Trend Forecasts

Emerging keywords refer to terms or subject headings that experience a significant sudden increase in usage frequency or attention within a specific timeframe. They effectively identify and track research hotspots and emerging trends that abruptly gain prominence in a particular field during a given period. These keywords reflect the dynamic shifts in research focus within the academic community and serve as crucial indicators for detecting disciplinary frontiers and predicting research trends.This study employed CiteSpace (6.4.R1) to detect salient words in Chinese vocational education research literature under the context of artificial intelligence from 2007 to

2024. With a one-year time slice, seven salient words were identified, as shown in Figure 7. Overall, the temporal distribution of these prominent terms exhibits continuous evolution, with a concentrated surge occurring after 2018. Their intensity remains relatively consistent, allowing the evolution to be divided into three distinct phases.

The first phase spanned from 2018 to 2020, with prominent keywords including "big data" (2018-2020), "development pathways" (2019), and "talent cultivation" (2020).This reflects that from 2018 to 2020, researchers collectively focused on three areas: big data in vocational education, development pathways for vocational education, and talent cultivation in vocational education. Notably, the evolution of keywords related to "big data" persisted for three consecutive years, making it the undisputed research hotspot of this phase.Reviewing the contextual backdrop of this initial phase, 2018 marked a pivotal development period for integrating artificial intelligence into China's vocational education. With the implementation of major policies such as the New Generation Artificial Intelligence Development Plan and the Education Informatization 2.0 Action Plan, AI advancement was elevated to a national strategic priority, making deep integration between education and industry imperative.As a vital component of the education system, vocational education serves as the primary channel for supplying skilled talent. Consequently, emphasizing the use of technologies like big data and artificial intelligence to drive transformation in vocational education models, build intelligent learning environments, enhance teaching quality and efficiency through information technology, and ultimately achieve personalized training has gained both practical significance and developmental expectations. This has become a focal point of shared interest among researchers.

The second phase of keyword evolution occurred in 2022, with the prominent terms being "professional development" and "curriculum system". This indicates that in 2022, researchers focused more on the development of vocational education programs and curriculum systems under the influence of artificial intelligence technology, with studies concentrating on more specific educational teaching and professional development scenarios.For instance, Wang Zhifeng (2022) proposed accelerating program upgrades, restructuring curriculum systems, and enhancing faculty members' digital literacy to advance program development[15]. Meanwhile, Nanjing Information Technology Vocational College enhanced its program development through initiatives such as co-authoring AI textbooks with industry partners, establishing AI industry integration platforms, launching new AI majors, and leveraging AI technology to upgrade program clusters[16].A review of the literature reveals that research during this period shifted its focus from single-technology applications to interdisciplinary integration and distinctive development. It also emphasized dynamic adjustment mechanisms, leveraging industry-academia collaboration to align with real-time industry demands, thereby optimizing program layout and resource allocation. Regarding curriculum systems, the emphasis was on competency development and practical application, exemplified by approaches such as modular course design[17], enhanced practical teaching[18], and industry-education integration-driven development[19].

The third phase of highlighted terms spans from 2023 to the present, with "visualization" and "digitalization" emerging as research frontiers. Although "visualiza-

tion”-related studies began in 2022, highly cited articles in this area first appeared in 2023, and the influence of such research has persisted to the present day.The network analysis results indicate that as of the end of 2024, research in both areas remains highly prioritized by scholars. These topics have become research hotspots, continuously influencing the field's development and can be regarded as emerging trends and frontiers. “Visualization” primarily manifests as innovations in research methodologies, with studies often employing techniques like knowledge graphs and thematic clustering to present the knowledge structure, hot topic evolution, and collaborative networks within the vocational education domain[20].Articles in this category peaked in 2022. While they exert some influence on current research, their recent data is not fully captured due to time constraints, indicating ongoing research potential. “Digitalization”, meanwhile, focuses on technology-enabled educational transformation, encompassing areas such as digital educational resource development, smart teaching environment construction, and virtual simulation training platform applications. It emphasizes leveraging artificial intelligence to drive digital upgrades in teaching models, management efficiency, and industry-education integration within vocational education.Research in both areas not only aligns with national strategic demands for advancing the digital transformation of vocational education but also provides theoretical foundations and practical pathways for building a new ecosystem for vocational education in the intelligent era. These studies exhibit a trend of continuous evolution, warranting further in-depth exploration by researchers.

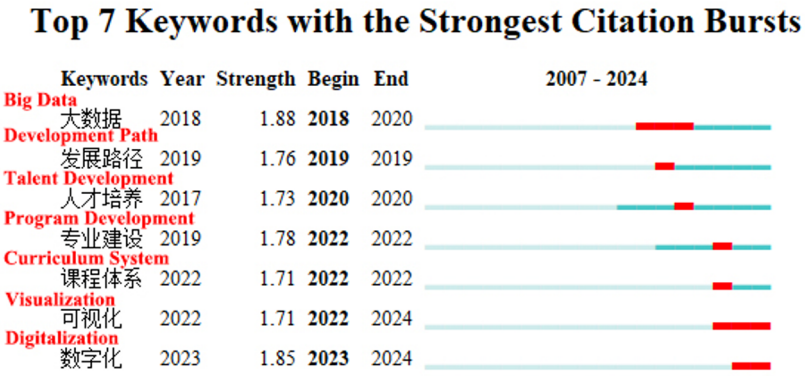

Fig. 7. Highlighted Word Map

5 Conclusion

The rapid advancement of artificial intelligence technology has driven accelerated transformation across various industries. Vocational education, which aims to cultivate skilled professionals, must also adapt to these changes to meet society's evolving demands. This has prompted scholars to engage in profound reflection on the essence and future trajectory of vocational education. This study employs co-word analysis

and utilizes the bibliometric analysis tool CiteSpace to conduct a systematic visualization analysis of the current state of China's vocational education development within the context of artificial intelligence. Empirical analysis leads to the following research conclusions.

5.1 Research on AI+Vocational Education in China has Progressed Through Three Distinct Developmental Stages

First, based on the stage of publication and the timeline mapping. According to the annual publication volume and timeline mapping statistics, research in vocational education in China under the backdrop of artificial intelligence can be divided into three stages: the “germination period”, “development period”, and “outbreak period”. The main research content and development directions of each period are discussed in detail. Second, from the perspective of authors. Scholars such as Huang Yao, Fang Xujun, Zhou Rujun, Fang Zhongxiong, and Li Zheng are core researchers in this field. Their articles are of high quality and significant influence, making it worthwhile to closely follow their research trends, which helps in understanding the direction of the field. Additionally, from the perspective of highly cited literature, three research directions have garnered attention in highly cited articles: “intelligent reform of vocational education teaching elements”, “intelligent education ecosystems and system transformation”, and “reconstruction of vocational competencies and adaptive strategies in the context of artificial intelligence”. These highly cited articles have an average citation count of over 60 and are published in core journals.

5.2 Identify Core Research Strengths and Structural Characteristics

This study found that among the institutions publishing research papers, vocational colleges and undergraduate universities each have their own strengths.Tianjin University of Technology and Education, Changzhou Vocational College of Information Technology, Tianjin University, Nanjing Institute of Technology, Sichuan Normal University, East China Normal University, and Beijing Normal University rank among the top research institutions. Key undergraduate institutions demonstrate higher publication quality, with core research units such as the Faculty of Education at Beijing Normal University (National Institute of Vocational Education), Tianjin University, and the Institute of Vocational and Adult Education at East China Normal University achieving high citation rates.Regarding institutional nature, vocational colleges contribute a high proportion of publications and involve a large number of participating institutions in this field. This indicates that vocational colleges are the main force in research, reflecting their distinctive research characteristics. Tianjin University of Technology and Education and Nanjing Institute of Technology stand out particularly for their high publication volume. Subsequent research should continue to focus on improving research quality to enhance article quality and citation rates.

5.3 Refine Three Highly Cited Themes and Ten Sub-research Directions

Based on the clustering results, under the context of artificial intelligence, overall research in vocational education can be divided into 3 highly cited themes and 10 research clusters. The highly cited themes include: research on the intelligent reform of vocational education teaching elements, research on intelligent education ecosystems and systemic transformation, and research on the reconstruction of vocational competencies and adaptive strategies. Sub-research directions include: talent cultivation in vocational institutions, pathways for industry-education integration and school-enterprise collaboration, digital transformation in vocational education, visualization of vocational skills instruction, technological empowerment in vocational education, vocational competencies and core literacy, transformation of teaching models, competency transition for vocational educators, employment outcomes in vocational education, and AI ethics and societal impacts. Each cluster has progressively differentiated into distinct research themes.

5.4 Predicting Future Research Frontiers and Development Trends

In terms of research content, during the development phase (2017-2022), researchers focused on topics such as vocational education talent cultivation, industry-education integration and school-enterprise collaboration, smart education and digital transformation in vocational education, pathways for cultivating professional competencies, and digital literacy in vocational education. When analyzing the evolution of prominent keywords, the research frontiers from 2018 to 2020 centered on “big data”, “development pathways”, and “talent cultivation”. By 2022, these evolved into “program development” and “curriculum systems”. During the explosive growth phase (2023 to present), research hotspots have shifted to human-machine collaboration in vocational education, smart dual-teacher teaching models, and curriculum-based ideological and political education in AI-enabled vocational education. Among these, “visualization” and “digitalization” have garnered significant attention from researchers and remain prominent to this day, indicating potential future research trends. Subsequent studies may evolve in these two directions.

Acknowledgments

This study was funded by 2024 Hunan Provincial Education Department Scientific Research Project “Knowledge Graph Measurement and In-depth Mining Research on the Development Path of Vocational Education under the Perspective of Artificial Intelligence” (grant number 24B1207); 2024 Research Project on Vocational Education Teaching and Reform by the Ministry of Education's Vocational Education Development Center : “Design and Practical Outcomes of an AI-Based Personalized Learning System for Higher Vocational Students” (grant number JZJG25194); 2023 Hunan Province Social Science Fund Project “Research on the Adaptability of Higher Vocational Education under the Employment Substitution Effect of Artificial Intelligence” (grant number 23YBQ142).

References

1. DEQUAN Z, QING X. The Tools and Principles of Technology: The Value Logic of Vocational Education .[J]. Educational Research, 2020, 41(12): 98-110.
2. YUE C, CHAOMEI C, ZEYUAN L, et al. Methodological Functions of the CiteSpace Knowledge Graph [J]. Studies in Science of Science, 2015, 33(02): 242-53.
3. ZUOYUN S, XIUXIA L. A Study on Author Keyword Standardization in Co-Word Analysis: Taking Library Personalized Information Services as an Example [J]. Information Science, 2012, 30(05): 731-5.
4. WENLAN Z, RUI S. Hotspots, Trends, and Insights in Overseas Project-Based Learning Research: A Data Visualization Analysis Based on CiteSpace [J]. Journal of Distance Education, 2018, 36(05): 91-102.
5. MIN W. Research on Clustering Algorithms for Categorical Attribute Data [D]; Jiangsu University, 2008.
6. ANG C. The Significance of Artificial Intelligence Development and Future Vocational Education Talent Cultivation [J]. Contemporary Vocational Education, 2017, (04): 11-5.
7. JIN Y. The Impact of Industry 4.0 on the World of Work and the Call for Educational Transformation [J]. Educational Research, 2020, 41(02): 124-32.
8. YUFEI W, ZHEN H. Artificial Intelligence Empowering Vocational Education: Current Forms, Underlying Mechanisms, and Practical Dimensions [J]. Chinese Journal of Distance Education, 2022, (05): 1-8+76.
9. RONGHUAI H. Accelerate the Digital Transformation of Education to Drive High-Quality Development in Schools [J]. People's Education, 2022, (Z3): 28-32.
10. YA Z, JINXING X, SHANXUE S. Research on Smart Teaching in Vocational Education Courses under the "Internet Plus" Paradigm [J]. Chinese Vocational and Technical Education, 2017, (23): 8-12.
11. LIWEN H, JIAN W. On the Transformation and Innovation of Vocational Education in the Era of Artificial Intelligence [J]. Journal of Nanjing Social Sciences, 2020, (10): 142-8.
12. GUOQING X, JINFANG C, BEIJIA J, et al. ChatGPT/Generative AI and the Future of Vocational Education [J]. Journal of East China Normal University(Educational Sciences), 2023, 41(07): 64-77.
13. JIANMEI Y, MINGHAN W, RUI X. Construction and Application of AI Dual-teacher Intelligent Teaching Mode of ESP Empowered by Digital Transformation [J]. Medical Education Research and Practice, 2024, 32(05): 634-41.
14. LI Y, ZHENXIAN H, WEIXIA J. The Value Orientation and Practical Innovation of IPTTIAC in Vocational Education Curriculum in the Digital Era [J]. Theory and Practice of Education, 2024, 44(27): 28-32.
15. ZHIFENG W. Exploring Professional Development in Higher Vocational Colleges from an "AI+" Perspective [J]. Education and Vocation, 2022, (21): 47-50.
16. LIANG W. Challenges, Key Focus Areas, and Reform Innovations in Vocational Education in the Era of Artificial Intelligence — Summary of the "AI+ Vocational Education Innovation and Development Forum" [J]. Chinese Vocational and Technical Education, 2022, (28): 90-5+88-9.
17. YU L. Exploring New Pathways for School-Enterprise Collaborative Education in the Context of Industry-Education Integration: The Case of iFlytek's Artificial Intelligence Engineer College [J]. Journal of Beijing Institute of Economics and Management, 2022, 37(02): 52-61.

18. SHIRU G, CHENGLIN W, YONGFENG G, et al. Analysis of Strategies for Cultivating Artificial Intelligence Talent in the Context of New Engineering Education [J]. Heilongjiang Science, 2022, 13(17): 90-2.
19. JUNJIE W. Vocational College Expansion and AI Iteration: Conflict or Synergy? —On the Transformation Logic and Innovation Pathways of Higher Vocational Education [J]. Zhejiang Social Sciences, 2022, (03): 99-106+59.
20. YING Z, YING C. Visual Analysis of Vocational Education Research in China Against the Background of Artificial Intelligence [J]. Contemporary Vocational Education, 2022, (01): 96-103.