Tracing the Digital Transformation of Higher Education in China: A Bibliometric Analysis of Research Trends (1998–2025)

Liu Ting, Xu Xi Wen and Ko Jang Wan

Abstract – **The digital transformation of higher education has gained significant momentum globally. As one of the world's largest higher education systems, China has undergone a substantial shift in research priorities and educational practices, driving an accelerated digitalization process that has attracted increasing international attention. Given its scale and rapid advancements, China serves as a key case for examining digitalization in non-English-speaking contexts, necessitating a systematic analysis of its developmental trajectory. This study employs bibliometric and network analysis to examine 1,144 articles indexed in the Chinese Social Sciences Citation Index (CSSCI) from January 1998 to April 2025, mapping the evolution of higher education digitalization research in China. The findings identify four distinct phases: (1) Exploratory phase (1998–2005), characterized by theoretical discussions on educational modernization and initial ICT infrastructure development; (2) Transitional phase (2006–2015), focusing on the integration of digital technologies into pedagogy, online learning, and resource construction; (3) Rapid expansion phase (2016–2021), marked by large-scale adoption of digital tools, MOOCs, and AI-driven education; and (4) Deepening phase (2022–onward), where intelligent learning ecosystems, big data, and digital governance have become central research priorities. Notably, research output surged post-2022, reflecting a growing emphasis on bridging theory with applied digital education. Keyword co-occurrence analysis highlights MOOCs, cloud computing, AI, big data, and the metaverse as central to China's higher education digitalization, driving advancements in personalized learning, teaching methodologies, and quality management. While research networks have formed, findings indicate a need for stronger institutional collaboration and international engagement. Moreover, digitalization plays a dual role in advancing educational equity and sustainability, underscoring its broader global relevance. This study provides a comprehensive examination of China's digital transformation, offering empirical insights for researchers, policymakers, and institutions navigating the evolving digital education landscape.**

Keywords – **Higher Education in China, Digital Transformation in Higher Education, Bibliometric Analysis, Scientific Visualization, Educational Technology Adoption, Keyword Network Analysis.**

I. INTRODUCTION

The digital transformation of higher education is reshaping how knowledge is created, shared, and experienced worldwide. Driven by advances in information and communication technologies (ICTs), the globalization of education, and the urgent pressures brought by the COVID-19 pandemic, the digitalization of educational systems has accelerated rapidly (UNESCO, 2022). In response, higher education institutions (HEIs) around the world have adopted diverse digital strategies to enhance teaching, learning, research, and institutional management. Multimedia teaching, online and blended learning, digital resources, and collaborative platforms have become common features across higher education landscapes (Brika et al., 2022). At the same time, digital transformation is not only enhancing the mechanics of education delivery but also shaping broader pedagogical models and fostering new approaches to cultivating innovation and critical thinking among students (Zhao et al., 2021).

Within this evolving global context, China offers a particularly compelling case for understanding the trajectories of educational digitalization. Although a latecomer compared to countries such as the United States, the United Kingdom, and Australia (Jing et al., 2020), China has, over the past two decades, made extraordinary strides in integrating digital technologies across its vast higher education system. Recognizing the strategic value of informatization and digitalization for talent development, educational reform, and national competitiveness, the Chinese Ministry of Education (MOE) has introduced a series of landmark initiatives, including the "Education Informatization 2.0 Action Plan" (MOE, 2018), to accelerate this transformation (MOE, 1998; 2012; 2016; 2021a; 2021b; 2022). By August 2021, the number of e-learning users in China had surpassed 325 million, accounting for over 32% of all internet users (CNNIC, 2021). Particularly in the wake of the COVID-19 pandemic, China rapidly transitioned from traditional classroom formats to fully online learning environments, setting new benchmarks for agility and scale in educational digitalization. In parallel, Chinese universities increasingly engaged in global initiatives, sharing e-learning platforms and technologies internationally, and forging closer ties with foreign HEIs (Liu & Ko, 2021).

Yet despite these impressive developments, scholarly research on China's higher education digitalization remains fragmented, especially in international academic discourse. Most existing bibliometric studies have focused on global trends, relying on databases such as Web of Science, Scopus, and Google Scholar (Guo et al., 2021; Rawat & Sood, 2021; Jing et al., 2020). While these studies offer valuable macro-level insights, they often miss the more nuanced dynamics unfolding within non-English-speaking contexts like China, where distinct national strategies,

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cultural frameworks, and technological ecosystems shape unique pathways of educational transformation.

Addressing this gap, the present study seeks to map the research development trajectories, major topics, and emerging trends within China's higher education digitalization by systematically analyzing Chinese-language academic outputs. Drawing on a bibliometric and network analysis of 1,144 articles published in the Chinese Social Sciences Citation Index (CSSCI) between January 1998 and April 2025, and employing CiteSpace software for co-occurrence and clustering analyses, this study aims to provide a more contextualized, data-driven understanding of China's evolving digital education landscape.

Specifically, the study addresses the following research questions:

(1) What are the publication trends and developmental trajectories of research on higher education digital transformation in China?
(2) What are the major research topics and emerging trends in studies on higher education digital transformation in China?

II. LITERATURE REVIEW

Higher Education Digitalization/Informatization in China

Since the late 1990s, the Chinese government has launched a series of strategic initiatives to promote the digital transformation of higher education. A major milestone was the Ten-Year Development Plan for Education Informatization (2011–2020), initiated in 2012 (Yan & Yang, 2021). This plan emphasized both infrastructure construction and application development, introducing the "Three Connections"—broadband access in every school, quality digital resources in every classroom, and online learning spaces for every student—as well as the "Two Platforms," national public-service systems for educational resources and management (MOE, 2012).

Following the plan's initial completion in 2017, the Ministry of Education introduced the Education Informatization 2.0 Action Plan to deepen digital transformation efforts (MOE, 2018). This initiative aligned with emerging technologies such as Internet+, big data, and artificial intelligence, signaling a shift from infrastructure building toward systemic integration across educational levels. Alongside these national strategies, the digital transformation of higher education in China has advanced rapidly. In this context, education informatization and digitalization typically refer not only to enhancing teaching and learning with modern intelligent technologies but also to the broader optimization of university systems, structures, and operations (Li et al., 2019). Over time, information technologies have facilitated more dynamic teacher-student interactions, expanded access to diverse learning resources, and fostered greater autonomy and adaptability among learners.

However, the digital transformation of higher education differs from that in primary and secondary education by its greater organizational complexity. As Liu (2011) notes, beyond classroom innovation, it involves reconfiguring university management systems, governance models, and institutional processes. Despite notable progress, several challenges persist. Strategic planning for informatization remains fragmented, often confined to isolated campus networks and standalone platforms; data sharing across departments is limited, perpetuating "information islands"; and comprehensive, scientific evaluation mechanisms for digitalization initiatives are still underdeveloped (Liu & Zhou, 2021).

In response, recent national strategies—particularly China Education Modernization 2035 and the Education Informatization 2.0 Action Plan—emphasize the need for deeper integration, innovation, and systemic reform. As frontier technologies such as artificial intelligence, big data, and blockchain continue to evolve, a more comprehensive and cohesive approach to higher education digital transformation has become not just desirable, but imperative for advancing China's educational modernization.

Review of Studies on Higher Education Digitalization Informatization

Over the past two decades, the digital transformation of higher education has become an increasingly prominent research focus, leading to the publication of numerous bibliometric studies. Bibliometric analysis and visualization tools, such as CiteSpace, offer quantitative approaches to examining scientific knowledge structures, tracing research trajectories, mapping intellectual contributions, and identifying emerging trends across academic fields (Chen, 2017; Chen et al., 2019).

Early bibliometric research on higher education digitalization largely concentrated on the application of advanced technologies. Rawat and Sood (2021), for example, explored research frontiers and hotspots in educational ICT applications through CiteSpace analysis, highlighting areas such as engineering education and ICT integration. Similarly, Brika et al. (2022) conducted a bibliometric review of e-learning research trends during the COVID-19 pandemic using tools like VOSviewer and KnowledgeMatrix Plus, identifying online learning, blended learning, and virtual learning as dominant themes between 2020 and 2021. Goksu (2021) focused on mobile learning, using VOSviewer and SciMAT to map influential countries, researchers, and emerging trends. Wang and Zhan (2021) applied CiteSpace to analyze artificial intelligence technologies in higher education from 2009 to 2019, with machine learning and neural networks emerging as key research hotspots.

However, most of these studies have concentrated on specific technological domains or global research patterns, often relying on English-language databases such as Web of Science, Scopus, and Google Scholar. Relatively few studies have systematically examined the broader developmental trajectory of higher education digitalization in non-English contexts, particularly within China's unique institutional and policy frameworks.

Notably, Yang (2018) conducted one of the few comprehensive bibliometric analyses based on the Chinese CNKI database, covering publications from 2000 to 2017.

Yang mapped research trends, keyword distributions, and thematic developments, identifying key topics such as information technology, cloud computing, education models, informatics literacy, virtual reality, and MOOCs. He further delineated three stages of research development: an early theoretical exploration stage (2006–2010), a transitional stage (2010–2014), and a practical application stage (2014–2017). While Yang's study offered valuable insights, it did not capture the initial emergence of informatization prior to 2000, nor did it reflect the significant paradigm shifts that have occurred since 2018—particularly the rapid acceleration of digital transformation triggered by the COVID-19 pandemic.

In sum, while previous bibliometric studies have illuminated important aspects of higher education digitalization, comprehensive analyses of China's developmental trajectory and intellectual structure remain scarce. Moreover, the predominance of English-language analyses has limited the global visibility of Chinese-language research outputs, despite China's increasingly central role in educational digital transformation.

To bridge these gaps, the present study systematically examines 1,144 articles published in the Chinese Social Sciences Citation Index (CSSCI) from 1998 to 2025. By tracing research trends, mapping thematic clusters, and visualizing emerging frontiers, this study seeks to provide a more contextualized, empirical understanding of China's digital transformation in higher education, and to contribute to expanding the international discourse beyond English-centric perspectives.

III. RESEARCH METHOD

Analysis Method and Visualization Tool

This study employed bibliometric analysis to systematically examine the research landscape of higher education digitalization and informatization in China. Bibliometric methods allow for the quantitative assessment of large bodies of literature based on attributes such as publication volume, author and institution networks, journal distribution, and keyword co-occurrence patterns (Chen, 2017; Chen et al., 2019). By leveraging automated data processing, bibliometric analysis mitigates potential researcher bias and offers a comprehensive view of developmental trajectories and intellectual structures (Donthu et al., 2021).

For data analysis and visualization, CiteSpace (Version 6.4.R1)—an open-source software developed by Chaomei Chen—was utilized. CiteSpace specializes in knowledge mapping through the analysis of bibliographic records from databases such as Web of Science, Scopus, CNKI, and CSSCI. Compared with tools like VOSviewer and SciMAT, CiteSpace is particularly effective in identifying pivotal nodes via betweenness centrality, detecting emergent research frontiers through burst analysis, and clustering thematic groups using the Log-Likelihood Ratio (LLR) method (Chen, 2017; Chen et al., 2019).

In the generated knowledge networks, nodes represent elements such as authors, institutions, journals, or keywords, and links denote the relationships between them. Node size reflects publication or citation frequency, while link thickness indicates the strength of connections. Visual cues such as purple rings (high centrality) and red inner rings (citation bursts) highlight influential or emergent areas. Through these analyses, the study captures both the structural foundations and the dynamic evolution of research in higher education digitalization.

Data Collection and Processing Procedure

The data for this study were sourced from the Chinese Social Sciences Citation Index (CSSCI), one of the major core academic citation databases in China, providing an authoritative foundation for the bibliometric analysis. The retrieval period spanned from January 1998 to April 2025, and only academic journal articles were included in the dataset to ensure the scholarly relevance and consistency of the analysis.

During the data retrieval process, three primary search terms were established: "Higher Education Informatization," "University/College Informatization," and "Higher Education Digitalization." The search was conducted across both the title and keyword fields. As outlined in Table 1, the search logic applied Boolean operators as follows:

(Keyword contains "Higher Education Informatization" OR Title contains "Higher Education Informatization") OR (Keyword contains "Higher Education Digitalization" OR Title contains "Higher Education Digitalization") OR (Keyword contains "University/College Informatization" OR Title contains "University/College Informatization") OR (Keyword contains "University/College Digitalization" OR Title contains "University/College Digitalization").

TABLE I: SEARCH QUERY IN CHINESE SOCIAL SCIENCE CITATION INDEX (CSSCI)

Data Source	Chinese Social Science Citation Index (CSSCI)
Search Query	((Keyword contains "Higher Education Informatization" OR Title contains "Higher Education Digitalization") OR (Keyword contains "University/College Digitalization" OR Title contains "University/College Digitalization") OR (Keyword contains "University/College Informatization" OR Title contains "University/College Informatization")). AND ((Year Between ('~','2023')) AND (CSSCI Journal='Y')).
Time Span	January 1998 to Apirl 2025
Document Type	Academic Article
Search Scope	Academic Journal
Number of Records	980

The dataset for this study was sourced from the Chinese Social Sciences Citation Index (CSSCI). To ensure the relevance and quality of the collected records, the search was restricted to academic articles published in academic journals, using an exact match retrieval method.

An initial total of 1,144 records was retrieved.

Following retrieval, a two-stage manual screening process was implemented. Records categorized as reports, conference proceedings, non-academic articles, or duplicate entries were excluded based on predefined research criteria. After this screening, 980 valid academic articles remained. Each record contained comprehensive bibliographic metadata, including author names, institutional affiliations, journal titles, publication years, abstracts, and keywords.

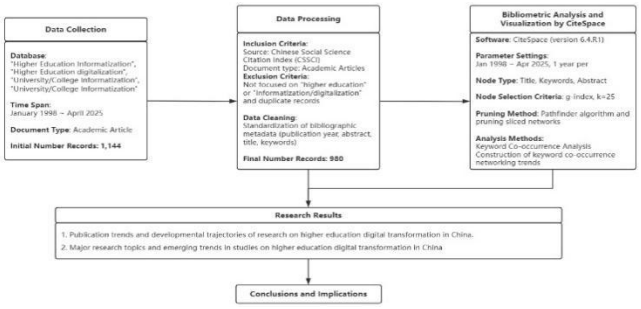

Figure 1. Flowchart of the Research Procedure

The structured metadata provided by the CSSCI database were then exported for further analysis. Data cleaning and standardization procedures were applied to correct inconsistencies in author names, institutional identifiers, and keyword formats. The processed dataset established a robust foundation for subsequent keyword extraction, topic modelling, and trend analysis through bibliometric techniques.

IV. RESULTS

Publication Trends and Development Trajectories

Research on higher education informatization/ digitalization in China began to emerge in 1998, as illustrated in Figure 2. From that year until December 2025, a total of 980 relevant academic articles were recorded. In the early years—particularly before 2005—the overall research output remained modest, with only 109 publications (11.12% of the total). Most studies during this period focused on conceptual innovations, such as new teaching models, basic infrastructure for informatization/digitalization, and the promotion of information literacy in response to the growing knowledge economy. The literature largely centered on policy narratives and theoretical discussions, with limited engagement in practice. This reflects an early academic response to national education reform efforts, though the research itself was still relatively narrow in scope.

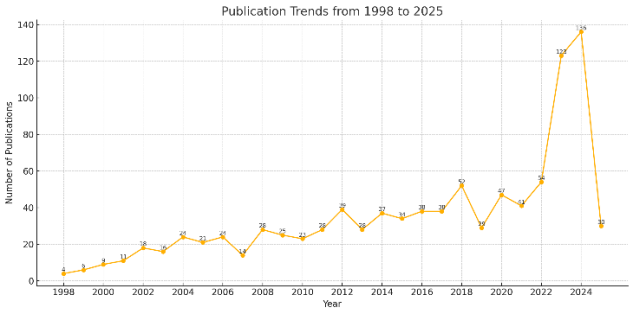

Figure 2. Publication Trends of the Studies on Higher Education Digitalization/Informatization in China

Between 2006 and 2015, scholarly interest began to grow. A total of 280 publications appeared during this decade, representing 28.5% of the total output. Research during this stage gradually shifted toward applied topics, including cloud computing, Internet+, distance learning, digital resource platforms, and the development of campus networks. There was a clear effort to connect theoretical frameworks with implementation, as seen in studies on smart campus planning, the evaluation of technology use, and digital management systems in higher education. While theoretical discussion remained important, research increasingly focused on how digital technologies could be integrated into the daily operations of universities.

After 2016, the field entered a period of accelerated growth. During this phase, 588 articles were published—accounting for 60% of the entire dataset. This surge aligned closely with national reform initiatives such as the 13th Five-Year Plan for Educational Informatization (Ministry of Education, 2016), which positioned digital transformation as a central strategy for higher education. At the same time, rapid advances in artificial intelligence—especially the rise of generative AI tools like ChatGPT since 2022—further expanded research topics. Studies began to focus more heavily on areas such as big data, MOOCs, digital literacy, AI applications, and the digital economy. Compared to earlier phases, the scope of research became significantly more diverse, with growing attention to both policy-driven objectives and emerging academic interests.

Taken together, the development of this field shows a clear trajectory: from early theoretical exploration to applied integration, and more recently toward diversified, technology-driven transformation. These shifts have been shaped by national strategies, infrastructure development, and changes in the broader academic landscape.

Keyword and Keyword Network Analysis

Keywords serve as the core representations of research topics and article content. Analyzing the frequency and centrality of keywords provides critical insights into major research focuses and emerging trends within a given field. In bibliometric networks, frequency indicates the prominence of a keyword, while centrality reflects its influence and connectivity within the network structure. Nodes with a centrality score exceeding 0.1 are considered particularly critical in bridging different clusters of knowledge (Chen, 2017; Chen et al., 2019). In this study, keyword co-occurrence analysis was employed to identify research hotspots and intellectual structures in the field of

higher education informatization and digitalization in China. Figure 3 presents the visualization of the keyword co-occurrence network from 1998 to 2025.

To better understand the thematic landscape of higher education digitalization research in China, this study conducted a keyword co-occurrence analysis based on publications from 1998 to 2025. As shown in Figure 3, the resulting network includes 600 nodes and 769 links, where each node represents a keyword and each link indicates their co-occurrence in the same publication. The size of a node reflects how frequently the keyword appears, while the thickness of a link shows the strength of the relationship. Nodes outlined in purple indicate high betweenness centrality, highlighting their role in connecting different areas of research.

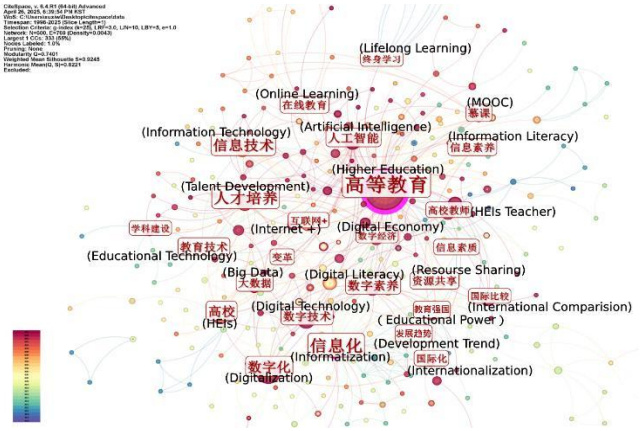

Figure 3. Visualization of the Keyword Co-occurrence Network (1998–2025)

Table 2 lists the top 20 keywords by both frequency and centrality. Not surprisingly, "Higher Education" appears most frequently (F = 185, C = 0.44), followed by "Informatization" (F = 48, C = 0.13) and "Digitalization" (F = 40, C = 0.10). These results confirm the central position of informatization in academic discussions around educational reform, digital capacity building, and technology-enhanced learning within Chinese universities.

In addition to these core terms, several keywords related to technological tools and platforms appear frequently in the network. "Information Technology," "Artificial Intelligence," "Digital Technology," "MOOCs," "Internet Plus," and "Big Data" are all notable examples. Their presence reflects growing research interest in how emerging technologies are reshaping higher education—from infrastructure and platforms to pedagogy and curriculum design.

Beyond the technological dimension, the appearance of keywords such as "Talent Development" (F = 29, C = 0.07), "Digital Literacy" (F = 11, C = 0.02), and "Educational Powerhouse" (F = 13, C = 0.01) points to broader national priorities. These terms suggest a focus on preparing digitally competent graduates, promoting lifelong learning, and elevating China's international standing in education. Other frequently mentioned terms, such as "Resource Sharing," "Lifelong Learning," and "International Comparison," reflect ongoing interest in equitable access, continuous learning, and global benchmarking within the digital education agenda.

TABLE II: KEYWORD FREQUENCY AND CENTRALITY OF THE TOP 20 KEYWORDS

No.	Keyword	Centrality (C)	Frequency (F)	Year
1	Higher Education	0.44	185	1998
2	Informatization	0.13	48	2002
3	Talent Development	0.07	29	2006
4	Digitalization	0.1	40	2010
5	Information Technology	0.05	27	2002
6	HEIs	0.05	19	2007
7	Resource Sharing	0.04	4	2008
8	Online Education	0.03	12	2013
9	Lifelong Learning	0.03	3	2001
10	Artificial Intelligence	0.02	21	2018
11	Digital Literacy	0.02	11	2023
12	Educational Technology	0.02	11	2002
13	Digital Economy	0.02	8	2022
14	MOOC	0.02	7	2016
15	Digital Technology	0.01	22	2009
16	Educational Power	0.01	13	2023
17	Development Trend	0.01	9	2007
18	International Comparison	0.01	9	2010
19	Internet +	0.01	9	2015
20	Big Data	0.01	8	2015

The burst analysis shown in Figure 4 highlights how research on higher education digitalization in China has shifted focus over time, often in parallel with national policy initiatives and technological developments.

In the early 2000s, terms like "Educational Technology" and "Informatization" saw the most noticeable bursts. These patterns reflect the field's initial focus on infrastructure development and the early adoption of ICT tools in education. By around 2010, the keyword "HEIs" began to rise in prominence, signalling a growing interest in how universities themselves—beyond the classroom—could adapt to digital reform, particularly in governance, strategy, and institutional modernization.

Between 2015 and 2022, the rise of terms such as "Online Learning," "Internet Plus," and "Big Data" marked a turning point. During this period, digital technologies were no longer seen as optional add-ons but became integral to teaching, administration, and global collaboration. The shift coincided with China's Internet+ strategy and widespread investment in digital infrastructure, paving the way for scaled-up online learning models and data-informed decision-making in education.

Since 2022, newer keywords such as "Artificial Intelligence," "Digital Literacy," "Digital Economy," and

"Digitalization" itself have gained sustained attention. This suggests that current research is increasingly focused on intelligent systems, personalized learning, and broader digital competencies—trends that mirror global priorities. The appearance of "Educational Powerhouse" in this context points to China's strategic ambition to lead globally in digital education development, as outlined in national visions like China Education Modernization 2035.

Taken together, the burst trends illustrate a clear trajectory: from foundational infrastructure and policy exploration, to practical technology integration, and now toward more advanced, intelligence-driven transformations. Throughout this evolution, research has grown to address not only internal system upgrades but also China's positioning in the global digital education landscape.

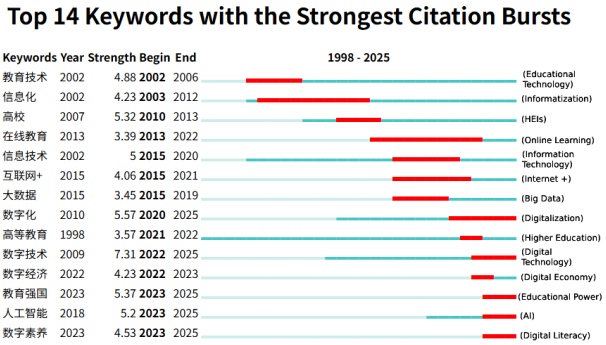

Figure 4. Top 14 Keywords with the Strongest Citation Bursts from 1998 to 2025

Keywords Clustering Analysis

To further understand the structure of research in this field, a keyword clustering analysis was conducted. Figure 5 illustrates the timeline visualization of cluster development, while Table 3 summarizes the top 10 clusters identified from CSSCI publications between 1998 and 2025. The clusters were generated using the log-likelihood ratio (LLR) algorithm, which assigns descriptive labels to each cluster based on the most representative keywords. The quality of the clustering is supported by a modularity score of 0.7008 and a mean silhouette score of 0.9419—both indicating a strong and reliable network structure.

The cluster analysis reveals several distinct phases in the development of higher education informatization/ digitalization research in China. Clusters #7 ("HEIs") and #8 ("Online Education") have average citation years around 2007, pointing to early interest in improving faculty information literacy and experimenting with digital teaching environments. These clusters reflect foundational concerns around building the basic infrastructure for digital learning.

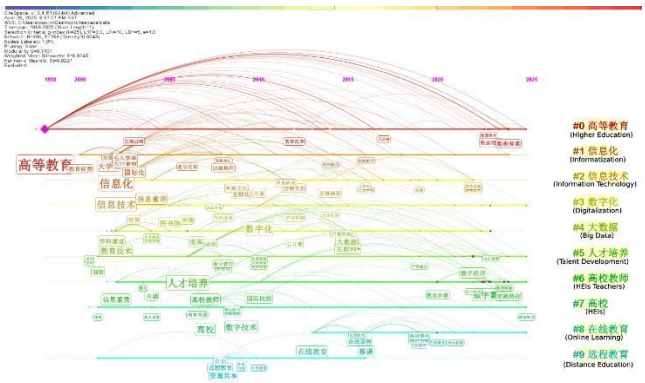

Figure 5. Keywords Clustering Timeline Visualization Map (1998-2025)

Clusters #0 ("Higher Education") and #2 ("Information Technology") are centered around 2009, a period marked by more structured efforts to establish digital systems across universities. The appearance of Cluster #6 ("College Teachers") in the same period further highlights the growing emphasis on capacity-building for educators as institutions moved from policy design to practical implementation.

Moving into the 2011–2013 period, Clusters #1 ("Informatization") and #4 ("Big Data") suggest a shift toward more applied, policy-aligned research. This phase coincides with national strategies advocating a distinct path of "informatization with Chinese characteristics," which elevated big data and IT systems as essential tools for improving educational quality and governance.

By 2016 and 2017, Clusters #3 ("Digitization") and #5 ("Talent Development") reflect the field's transition into a new stage of research. The focus began to shift from technological infrastructure to broader questions of educational transformation—such as how digital tools support innovation, reshape teaching models, and cultivate skills for a digital future. This evolution underscores a growing alignment between academic inquiry, policy priorities, and technological advancement.

TABLE III: SUMMARY OF TOP 10 CLUSTERS OF HIGHER EDUCATION INFORMATIZATION IN CHINA FROM 1998 TO 2025

No.	Cluster Size	Silhouette value	Label (LLR Value)	Mean (cite year)
#0	57	0.888	Higher Education (50.45****)	2014
#1	41	0.869	Informatization (50.45****)	2008
#2	29	0.945	Information Technology (39.38****)	2013
#3	26	0.924	Digitalization (48.56****)	2011
#4	26	0.907	Big Data (26.64****)	2011
#5	25	0.921	Talent development (32.66****)	2015
#6	25	0.907	HEI teachers (25.95****)	2016
#7	22	0.914	HEIs (37.47****)	2007
#8	17	0.984	Online learning (25.158****)	2007

#9	9	0.986	Distance education (20.58****)	2013

Major Research Trends and Frontiers

(1) Construction of University IT Infrastructure and Policy Environment

Much of the existing research on digital transformation in Chinese higher education has concentrated on four main dimensions: infrastructure development, information resource construction, practical application of digital tools, and systemic support mechanisms. For instance, Zhang and Wang (2013) conducted a study in Henan Province using surveys and interviews to assess the status of informatization across these four areas. Their findings offered early empirical insight into the structural foundations of higher education informatization at the regional level. Gao, Fang, and Fan (2015) focused on the evolution of digital resource construction and teaching practices. They emphasized that digitalization not only alters instructional tools but also requires a fundamental shift in teaching methods, learning behaviours, assessment systems, and the teacher-student dynamic—elements that differ significantly from traditional education models. From a comparative lens, Liu and Zhao (2012) analyzed the internal and external environments shaping informatization in China and the United States. Their work highlighted the structural and strategic gaps between China's digital education systems and those in more mature, developed contexts.

In addition to system-level analysis, researchers have also identified key challenges in the ongoing process of digital transformation. Xiong, Dai, and Ge (2018) argued that the absence of unified evaluation frameworks has hindered the implementation of effective digital strategies. They proposed a set of comprehensive indices and principles for assessing informatization progress. Qu (2017) pointed to limitations in the allocation of digital resources and the shortage of skilled professionals in educational technology. To address these issues, she recommended raising institutional awareness, updating outdated management mindsets, improving sharing mechanisms, and expanding training programs. Liu (2019), taking a more balanced view, acknowledged current constraints in knowledge system development and digital infrastructure. Nonetheless, her research suggested that informatization has played a transformative role in modernizing pedagogy, diversifying instructional methods, and enhancing the availability of learning resources.

Overall, we suggests that sustained investment in infrastructure and the development of robust evaluation frameworks remain essential to supporting the next phase of digital transformation in Chinese higher education. At the same time, addressing human capital and institutional capacity remains a critical component of a more holistic and sustainable digital ecosystem.

(2) Enhancement of Teachers' Information Literacy and Digital Teaching Transformation

Another key area of scholarship has examined how improving teachers' digital competencies can support the broader digital transformation of teaching and learning in higher education. For example, Bi and Ma (2023) explored the integration of digital tools into college physics experiments, noting that technologies such as cloud computing, big data, and AI applications—including tools like ChatGPT—helped increase student engagement and reduce the repetitiveness often associated with traditional experimental formats. Their study emphasized how technology can reshape not only instructional delivery but also classroom dynamics.

Zhang, Zhao, and Shan (2022) investigated how E-Learning platforms influence pedagogical structures more broadly. Their findings pointed to notable changes in curriculum design, resource allocation, and the development of students' independent thinking and learning capacities—highlighting the pedagogical potential of digitalization beyond content delivery. Li and Zhang (2013) approached the topic from a practical angle, focusing on the integration of informatization into classroom practice. Their work emphasized the construction of IT-supported teaching platforms and multimedia-enhanced instruction as strategies for facilitating deeper engagement with both content and digital tools.

Together, these studies underscore the importance of strengthening faculty capacity for digital teaching, not only by upgrading technical skills but also by rethinking pedagogical models. Supporting teachers through targeted training, resource access, and instructional innovation remains central to advancing sustainable digital transformation in higher education.

(3) Integration of Big Data and Artificial Intelligence into Educational Applications

Recent studies have begun to emphasize the expanding influence of big data and artificial intelligence on both research and operational practices in higher education. Bi and Ma (2023), for instance, pointed out that the rise of the big data era has brought about a fundamental rethinking of how higher education is studied and managed. Drawing on four analytical dimensions—institutions, academic activities, research content, and outcomes—they illustrated how large-scale educational data are being used to monitor performance, forecast learning trajectories, and assess institutional effectiveness in more granular ways.

Beyond research design, the integration of AI technologies into daily academic operations is also accelerating. Algorithms are increasingly used to support personalized learning environments, automate administrative processes, and detect patterns in student behaviour that may indicate disengagement or academic risk. These applications reflect a broader shift from intuition-based decision-making to data-informed strategies, which allow institutions to respond more proactively to complex educational challenges.

While the benefits are evident, this transition also

raises important questions about data privacy, algorithmic transparency, and the readiness of institutions to interpret and act on such information meaningfully. As such, the growing presence of big data and AI does not merely represent a technological upgrade—it signals a deeper structural transformation in how knowledge is produced, managed, and acted upon in the digital university.

Taken together, these developments point to a rapidly emerging model of data-driven governance and pedagogy in Chinese higher education—one that has the potential to enhance both institutional efficiency and student success, but also demands thoughtful safeguards and continuous capacity building.

(4) Educational Digital Transformation and Innovation-driven Development

A growing strand of research has turned attention to how digital transformation enables innovation-driven reform across higher education systems. Yang (2021) emphasized that harnessing the full potential of information technologies requires continuous innovation in teaching practices, while also maintaining coherence with traditional pedagogical values. In his view, innovation should not simply replace existing methods but evolve from them, forming a hybrid model suited to the demands of the digital age. Building on this perspective, Guo and Yang (2018) examined the emergence of digital campuses as a key driver of institutional transformation. Their work suggests that digitalization does not only alter the delivery of education but fundamentally reshapes how universities operate—from resource allocation and management systems to communication structures and academic cultures.

A key theme across these studies is the evolving role of educators. Guo and Yang point out that for digital transformation to take root, it must be embraced not only at the technical level but also in educators' mindsets and daily professional behaviour. Digital tools alone cannot drive change without corresponding shifts in institutional norms and individual practices. What emerges from this study is a view of digital transformation as a catalyst for broader system-level change—enabling not just instructional innovation, but also new forms of academic governance, campus culture, and institutional adaptability in an increasingly digital and uncertain world.

V. CONCLUSIONS AND IMPLICATIONS

Conclusions

This study applied bibliometric and network analysis methods to examine research trends and thematic developments in the field of higher education digital transformation in China between 1998 and 2025. Drawing on 980 academic articles retrieved from the Chinese Social Sciences Citation Index (CSSCI), the analysis was conducted using CiteSpace to visualize keyword co-occurrence networks, identify thematic clusters, and trace the evolution of research priorities over time.

The results show a marked growth in research activity over the past two decades, particularly after 2020. This surge aligns with the accelerated adoption of emerging technologies such as artificial intelligence, big data, and cloud computing in the education sector. Chinese universities are increasingly confronted with new demands in teaching model innovation, data governance, and digital competency development. The research output reflects a broader institutional shift toward more integrated and technology-driven approaches to education.

The developmental trajectory of this field can be understood in four distinct phases. The exploratory phase (1998–2005) was shaped by policy discourse and theoretical reflection on modernization through informatization. The transitional phase (2006–2016) focused on infrastructure building, resource integration, and the introduction of digital tools into educational practice. A rapid expansion phase (2017–2023) saw the proliferation of research on MOOCs, AI-driven learning, and smart campuses, along with a strong orientation toward practical implementation. Since 2024, the field has entered a deepening phase characterized by intelligent ecosystems, big data governance, and institutional transformation under the broader agenda of digital transformation.

Keyword and cluster analysis reveal three dominant thematic axes: (1) foundational topics such as informatization, higher education, and information technology; (2) emerging technologies including big data, artificial intelligence, cloud computing, and "Internet Plus"; and (3) systemic challenges and strategic goals, such as faculty development, digital literacy, online education, and talent cultivation. This pattern reflects a gradual but consistent shift from infrastructural concerns to issues of institutional capability and long-term strategic planning.

As China continues to implement national strategies such as Education Informatization 2.0 and China Education Modernization 2035, future research should not only track the application of frontier technologies—such as blockchain and the metaverse—but also critically assess their pedagogical, ethical, and policy implications. Strengthening interdisciplinary collaboration, improving evaluation mechanisms, and developing localized models of digital transformation will be key to enhancing the sustainability and global competitiveness of China's higher education system in the digital era.

Implications

Although this study highlights significant progress in the field of higher education digital transformation in China—both in terms of research volume and thematic expansion—several limitations and gaps remain.

First, the body of research on policy analysis is relatively limited. Most studies focus on macro-level overviews of national or provincial strategies, with far less attention paid to detailed interpretations of specific policy content or implementation mechanisms (Hu, 2021; Liu & Zhou, 2021). This has led to a disconnect between strategic planning and ground-level educational practice.

Second, current studies on the integration of digital technologies into teaching largely concentrate on English language instruction, with insufficient exploration of other

academic disciplines. While a growing number of publications address curriculum reform and pedagogical change, subject-specific analysis—particularly in STEM fields and interdisciplinary programs—remains underdeveloped (Huang et al., 2022; Zhang et al., 2022).

In terms of digital infrastructure and platform development, earlier work was focused on the construction of libraries, campus networks, and digital campuses. More recent studies have expanded to include emerging topics such as virtual laboratories, MOOCs, smart campuses, cloud computing, and learning analytics. However, much of the research remains descriptive, lacking detailed empirical evaluation or comparative case studies of implementation across institutions (Guo & Yang, 2019; Bi & Ma, 2023).

Additionally, many publications tend to reiterate known challenges—such as digital equity, resource allocation, or teacher training—without offering novel conceptual frameworks or localized strategies. There is also a noticeable shortage of project-based analysis or evaluations of pilot models, limiting the practical applicability of the findings (Liu, 2019; Peng et al., 2021; Qu, 2017).

In response to these issues, several directions for future research can be proposed. First, there is a need to broaden the scope of study beyond policy-level summaries toward detailed policy interpretation and field-level implementation analysis. Comparative studies that examine how digital transformation unfolds in different institutional or regional settings—including both developed and developing countries—would provide useful insights. Moreover, expanding the empirical base through mixed methods research, including case studies, surveys, and interviews, can enhance the credibility and depth of findings.

Second, theoretical foundations in this field should be strengthened. While many studies focus on technology adoption, relatively few contribute to building conceptual models grounded in China's higher education context. Research should pay closer attention to human factors, including faculty development, digital literacy training, institutional leadership, and the governance structures needed to support sustainable transformation.

Finally, this study acknowledges several methodological limitations. The dataset was limited to publications indexed in CSSCI, and therefore may not fully reflect international scholarship or grey literature. The classification of keywords and clusters relies on co-occurrence algorithms and network logic, which are inherently shaped by software settings and subjective interpretation. Furthermore, this study has primarily focused on technological and structural dimensions of digital transformation; future research could expand to address cultural, ethical, or pedagogical perspectives, particularly in the post-COVID-19 landscape where educational models continue to evolve.

Overall, deeper engagement with institutional realities, localized implementation strategies, and the human dimensions of digital change will be essential in advancing both the academic study and practical success of higher education digital transformation in China.

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