A Bibliometric Study of Digital Tools for Educational Effectiveness in Chinese Higher Education (2015–2025)

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ABSTRACT

The rapid advancement of digital technology has transformed higher education, offering significant potential to enhance teaching effectiveness, student engagement, and academic decision-making. In China, this transformation has been accelerated by strong government policies, institutional readiness, and cross-sector collaborations, making the country a global leader in digital education implementation. However, despite this rapid growth, research on digital tools in Chinese higher education remains fragmented, often focusing on specific technologies without a comprehensive mapping of trends, thematic developments, and collaborative networks. This study addresses that gap by conducting a bibliometric analysis of research on digital tools for educational effectiveness in China, identifying emerging topics, key contributors, and knowledge structures. Using bibliometric analysis with VOSviewer, 174 relevant publications from the Scopus database (2015–2025) were analyzed based on inclusion criteria. The analysis examined publication trends, productive authors and institutions, funding sponsors, keyword co-occurrence, and thematic clusters. Results indicate a significant increase in publications since 2020, peaking in 2025, with dominant contributions from institutions in Beijing and Shanghai. The most prominent research themes include computational learning systems, immersive digital technologies, artificial intelligence applications such as ChatGPT, and machine learning for personalized education. Novel keywords—such as ChatGPT, digital storytelling, contrastive learning, personalized learning, and digital transformation—highlight the evolution of research toward adaptive, data-driven, and AI-enhanced educational models. This study provides actionable insights for policymakers, educators, and researchers to strengthen digital integration strategies, address implementation challenges, and foster equitable, high-quality education in the digital era.

1. Introduction

The development of digital technology has had a significant impact on various aspects of life, including the field of education. In particular, higher education has undergone a technological revolution that has brought substantial changes to pedagogical processes and approaches to technology

integration in education [1]. These technologies now play a vital role in enhancing the effectiveness of teaching and learning [2], [3], [4]. The use of digital platforms and content in education requires alignment with updated curricula and academic procedures, with a strong emphasis on the adoption of technology-based tools as a top priority [5].

This transformation is evident in the widespread adoption of digital tools such as learning platforms, educational applications, technology-based assessment systems, and artificial intelligence (AI) to support teaching and learning processes [6]. In modern education, digital tools such as interactive platforms, virtual environments, and gamification elements have been extensively utilized to enhance students' learning experiences [7], [8].

Digital tools are defined as the use of electronic technologies to enhance teaching and learning, involving communication between students and instructors through online learning platforms [9]. Beyond serving as a medium for delivering content, digital tools now play a critical role in supporting academic decision-making, shaping educational policies, and strengthening communication and collaboration among educational stakeholders [10]. In the teaching and learning process, educators are expected to design digital tools that can capture students' attention and prevent boredom [11]. A wide range of digital devices and services have been developed to support learning activities, including recording audio and video clips, creating animations and graphics, managing digital portfolios, and organizing collaborative work on projects or information searches via the internet [12].

The integrity of digital tool usage for educational effectiveness refers to the application of digital technologies that are not only technically efficient but also ethically, equitably, and academically responsible. Implementation presents significant challenges in operational, pedagogical, and policy contexts [13]. These factors influence the effectiveness of digital tools in enhancing student engagement, academic collaboration, and learning outcomes. Even in higher education institutions with high levels of technology adoption, successful implementation still heavily depends on the availability of adequate digital tools. Many critical funding allocations for these technologies remain incomplete or are only in the early stages of development [14].

Many higher education institutions (HEIs) around the world have adopted various approaches to enhance the quality of education through the use of digital tools, particularly in the form of e-learning platforms [15]. Within this global context, China holds a prominent position as a country with one of the most proactive and structured digital education policies. The implementation of digital technologies in higher education is strongly supported by national government policies that emphasize the importance of digital transformation in the education sector. Numerous universities in China have developed advanced online learning platforms that leverage artificial intelligence (AI), big data, and learning analytics to personalize students' learning experiences [16]. In addition, collaboration between the education sector and the technology industry has further accelerated innovation in content delivery, learning assessment, and the development of 21st-century skills [17].

The successful integration of digital technology in China serves as an important reference for other countries that are striving to promote the systematic and sustainable digitalization of education. As shown in Fig. 1, China emerges as the most dominant country in contributing research related to the use of digital tools in higher education, with a significantly higher number of publications approaching 200 documents compared to other countries. Therefore, China can be regarded as a central hub for the development and study of digital technology integration in higher education.

Nevertheless, despite the continued growth of digital technology use in Chinese higher education, there remains a gap in the scholarly literature that comprehensively maps thematic trends, institutional contributions, and the intellectual structure of research in this field. Most previous studies have been descriptive in nature or focused on specific technologies, lacking a systematic, data-driven approach to identify the broader dynamics of research development.

A bibliometric analysis of the literature on digital tools in Chinese higher education over the past decade provides valuable insights into the development of scholarly knowledge, major research trends, and existing gaps amid the ongoing transformation toward increasingly digitalized learning systems

[18]. This study aims not only to map the direction and dynamics of research on the effectiveness of digital tools in the context of Chinese education, but also to explore their practical impact on improving teaching quality, student engagement, and learning outcomes.
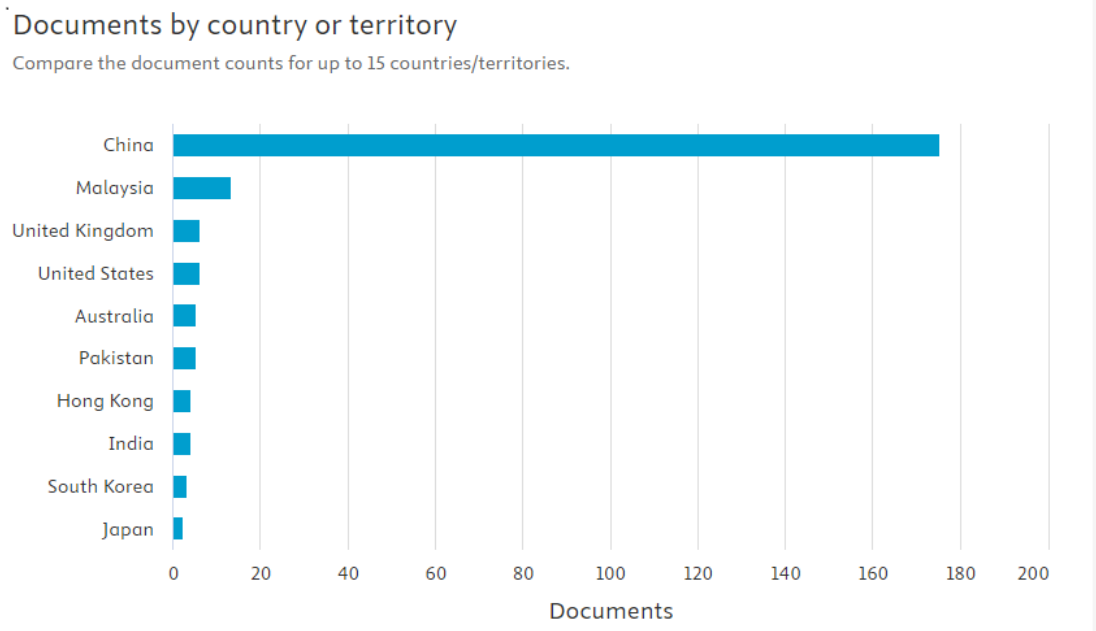

Fig. 1. Documents by Country

Urgency of this study lies in the need to comprehensively understand how digital tools are being utilized within the context of higher education in China, particularly given the rapid digital transformation occurring in the education sector. Although there has been a growing number of publications addressing this topic, much of the existing research remains fragmented and lacks a comprehensive mapping of trends, collaborations, and scientific contributions. Therefore, this bibliometric study is crucial for identifying the direction of research development, knowledge gaps, and potential areas for future investigation. Such insights can support evidence-based decision-making in the development of effective and sustainable digital education [19], [20]. Accordingly, this paper aims to explore and analyze the literature on the effectiveness of digital tool usage in Chinese higher education through a bibliometric approach. This analysis seeks to identify key research topics, the most productive authors and institutions, the most frequently cited sources and articles, as well as collaboration patterns within the field. The objectives of this study are as follows:

1. To identify the most productive literature related to the use of digital tools.
2. To determine the key topics that are the main focus of current research.
3. To identify the core keywords within the domain.
4. To investigate potential topics and themes for future research

This study seeks to answer the following research question and sub-questions:

RQ1: What is the current status and major research trends regarding the use of digital tools for educational effectiveness in higher education in China?

SRQ1: Which articles are the most highly cited?
SRQ2: Which journals are leading the literature in this field?
SRQ3: What are the main topics and themes being investigated?
SRQ4: What are the most frequently researched keywords?
SRQ5: Which institutions or affiliations contribute most to the body of research?
SRQ6: Who are the primary sponsors funding this research?

RQ2: What potential topics and themes can be explored in future research.

2. Method

This study is a bibliometric analysis aimed at exploring trends and contributions related to the use of digital tools in enhancing educational effectiveness in China. The search strategy was conducted through the Scopus database using the search string: TITLE ("digital tools") AND TITLE (educat*).

Subsequently, the screening process was carried out systematically by following the PRISMA protocol to ensure the quality and relevance of the data used (Fig. 2). Each article identified during the initial search stage was assessed based on its title and abstract to determine its alignment with the research focus, namely the implementation of digital tools in higher education in China. This assessment involved verifying the research context, topical relevance, and compliance with the specified study scope. From the initial total of 24,457 articles, 24,283 were excluded for failing to meet the eligibility criteria, such as addressing topics outside the higher education sector, examining digital tools in non-educational contexts, or focusing on countries other than China.
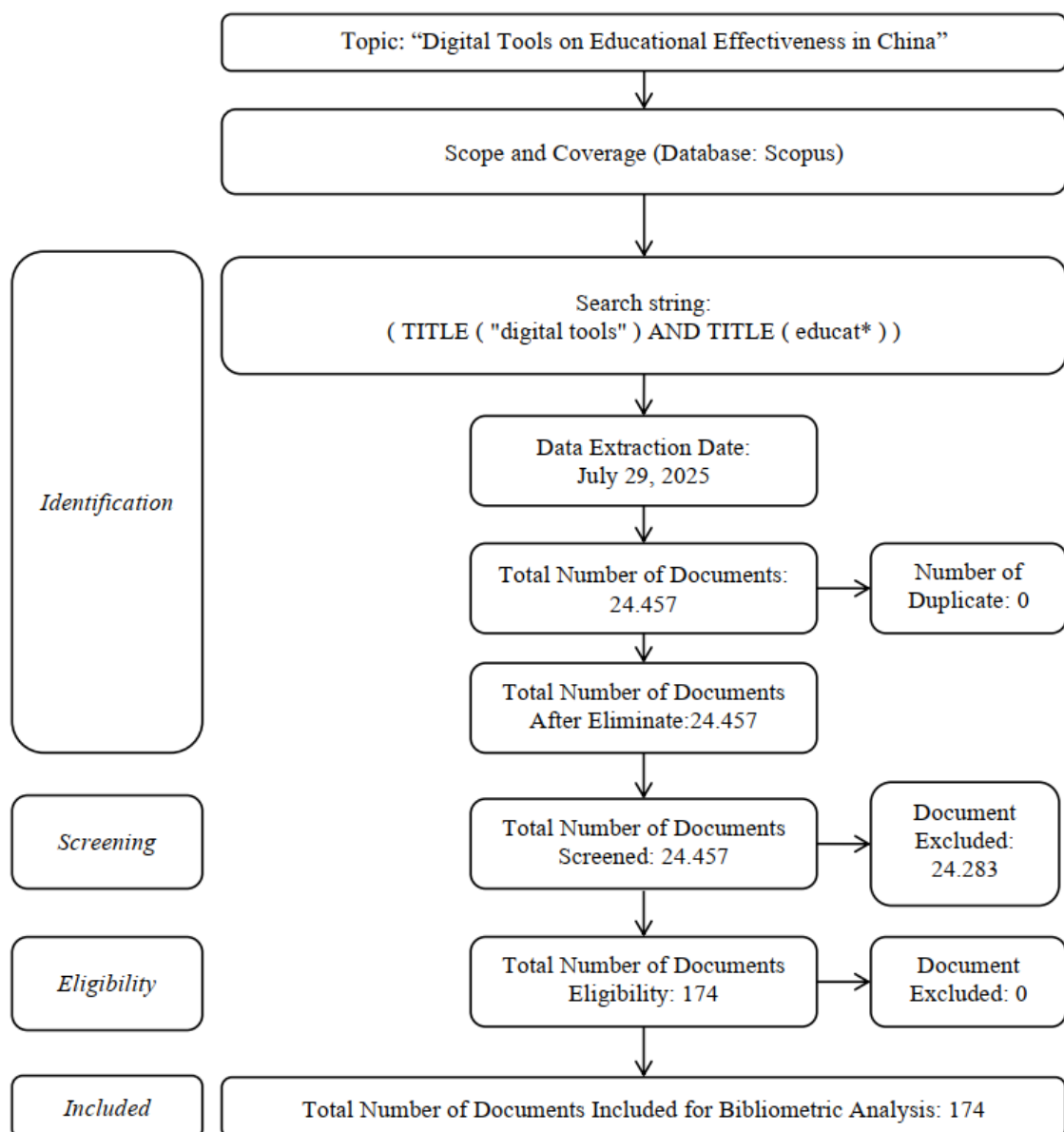

Fig. 2. The proposed method

Following this rigorous selection process, 174 articles were deemed relevant and met the inclusion criteria for further analysis. These articles formed the basis of the bibliometric study. Data analysis was complemented by network visualization using VOSviewer, which enabled the mapping of co-authorship relationships, keyword co-occurrence patterns, and co-citation linkages between documents. This approach provided a comprehensive overview of the research landscape, including collaboration patterns, thematic focuses, and the evolution of knowledge within the field of digital tools for educational effectiveness in Chinese higher education.

The inclusion criteria were: (1) studies focusing on the use of digital tools in an educational context, specifically in China; (2) publications from 2015–2025; (3) articles published in Scopus-indexed journals; and (4) English-language articles. The exclusion criteria were: (1) non-academic publications such as editorials, short reviews, or opinion papers; (2) articles that did not explicitly address the relationship between digital tools and educational effectiveness; and (3) documents unavailable in full-text format.

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3. Results and Discussion

3.1. Documents by Year Digital Tools for Educational Effectiveness in Chinese Higher Education

Based on the annual document distribution graph (Fig. 3), it is evident that publications related to digital tools and educational effectiveness in China have experienced a notable increase since 2020. From 2015 to 2019, the number of publications remained stagnant, with fewer than five articles published annually. However, a gradual upward trend began in 2020, culminating in a significant surge in 2025, which recorded 57 scientific publications focused on the use of digital tools in education. This increase reflects the growing attention of researchers toward the integration of digital tools in higher education. Consequently, this topic demonstrates rising relevance and strong potential as a strategic field of study for the future.
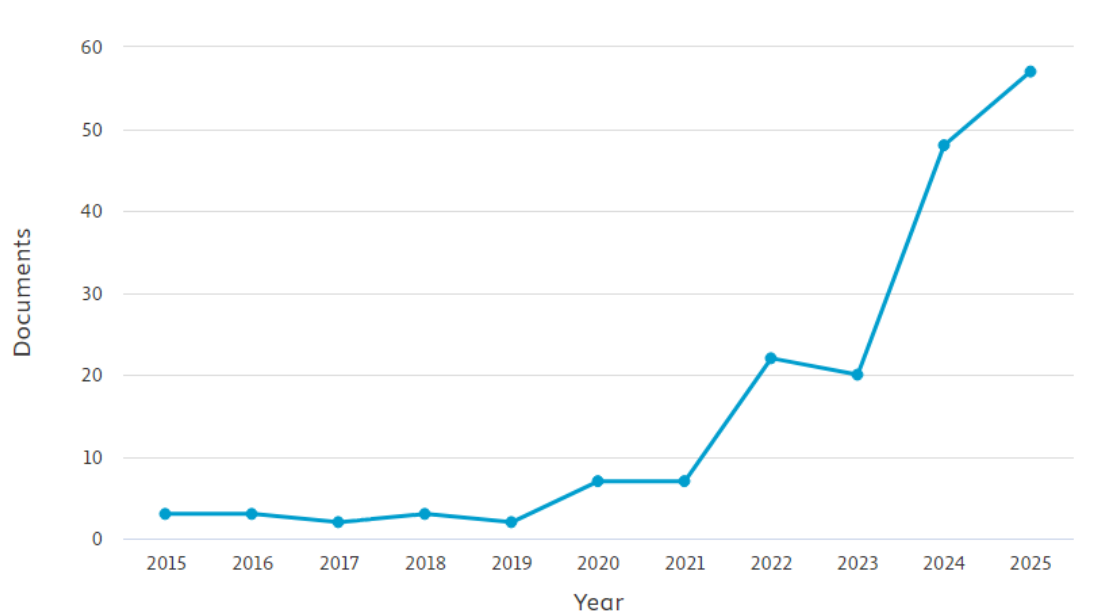

Fig. 3. Visualization Documents by year

3.2. Documents per Year by Source Digital Tools for Educational Effectiveness in Chinese Higher Education

Based on the "Documents per Year by Source" graph (Fig. 4), it can be concluded that the development of publications on the use of digital tools for educational effectiveness in China is distributed across various scholarly sources, with a significant upward trend observed in the past two years. One of the most dominant sources is Applied Mathematics and Nonlinear Sciences, which recorded the highest surge in publications in 2024, with a total of six documents. This indicates a growing interest among researchers in applying quantitative and mathematical approaches to studies on digital educational effectiveness.
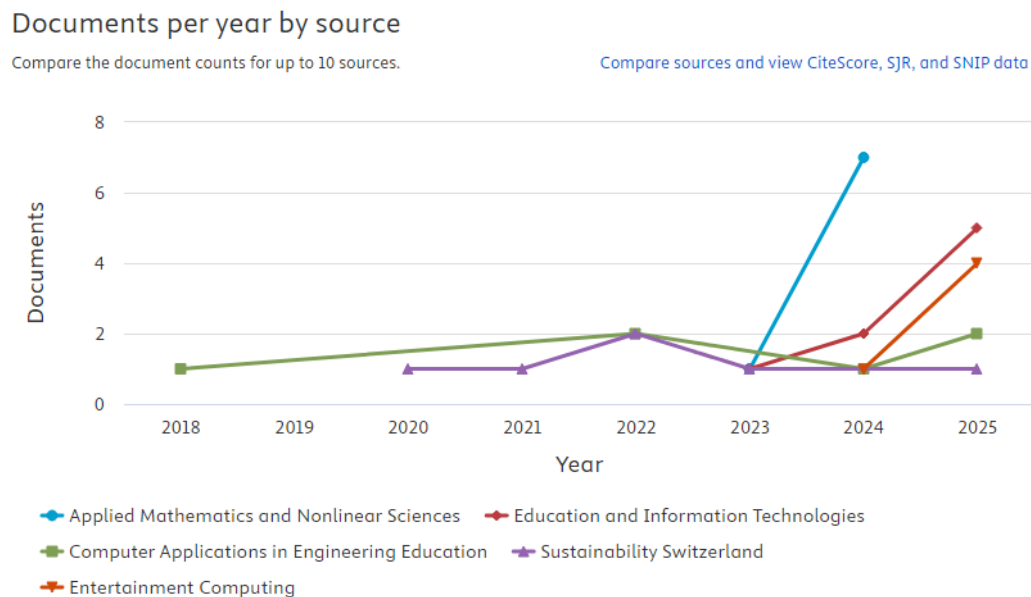

Fig. 4. Documents per year by source

Another consistently contributing source is Computer Applications in Engineering Education, which has maintained a stable trend, publishing an average of one to two documents annually since 2018. Education and Information Technologies have also shown notable growth, particularly in 2024, with four published documents. Additionally, Entertainment Computing recorded an increase in publications during the same period, reflecting an emerging interest in developing interactive entertainment media for learning purposes. Overall, this trend demonstrates a diversification of publication sources and highlights the increasing relevance of research on educational digitalization in the Chinese context.

3.3. Documents by Subject Area Digital Tools for Educational Effectiveness in Chinese Higher Education

Fig. 5 illustrates the distribution of published documents across various subject areas related to the use of digital tools for educational effectiveness in China. The most dominant field is Computer Science, accounting for 32.2% of the total publications, highlighting the central role of computational technology in supporting educational innovation. Social Sciences ranks second with a contribution of 26.5%, reflecting an interdisciplinary approach that considers the social dimensions of educational technology implementation. Engineering also makes a significant contribution at 13.5%, followed by Mathematics (6.2%) and Arts and Humanities (3.8%), collectively demonstrating a diversity of research perspectives. Meanwhile, other fields such as Business and Management, Medicine, Psychology, Energy, and Materials Science each contribute less than 3%, with the other category comprising 7.6% of the total publications. These findings indicate that research on the effectiveness of digital tools in China is predominantly driven by the disciplines of computer science and social sciences, yet remains collaborative by involving a broad range of academic fields.
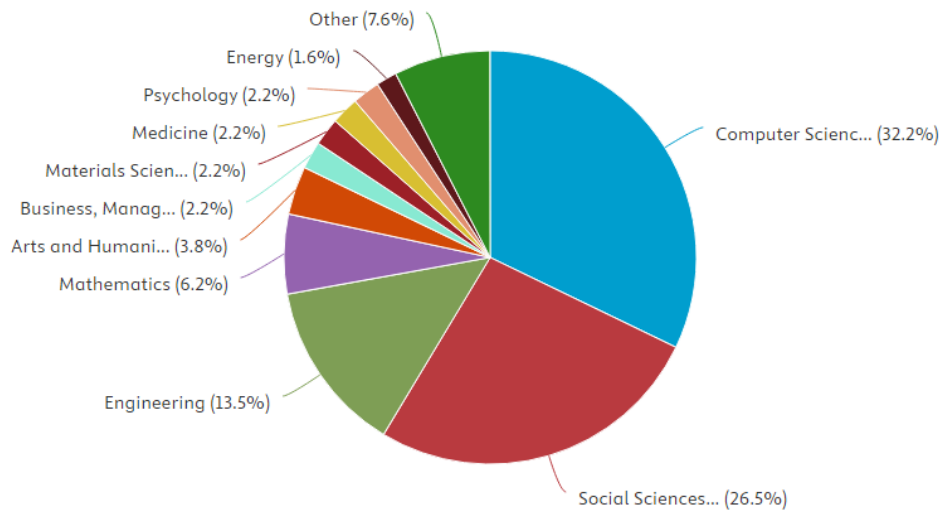
Fig. 5. Documents By Type

3.4. Documents by Affiliation Digital Tools for Educational Effectiveness in Chinese Higher Education

Based on the institutional affiliation data contributing to publications on Digital Tools for Educational Effectiveness in China, it is evident that the distribution of documents and citations spans several leading universities across the country (Table 1). Shanghai University ranks first in terms of citation count, with 230 citations from only 2 documents, indicating a substantial impact despite a relatively small number of publications. Peking Union Medical College Hospital also demonstrates significant influence, with 2 documents garnering 131 citations, highlighting the high quality and relevance of its research in this field.

Meanwhile, Beijing Normal University recorded the highest number of publications, with 6 documents, although its total citation count (70 citations) is lower than that of some institutions with fewer publications. This suggests a more evenly distributed citation impact per article. Other institutions, such as Beihang University, Guangxi Normal University, and Xi'an Jiatong-Liverpool University, also actively contributed to the field, with citation counts ranging from 40 to 59, reflecting solid recognition from the academic community.

Geographically, the major research hubs are concentrated in Beijing and Shanghai, which dominate the top ten affiliations with the highest publication impact. This underscores the crucial role of universities and research institutions in major cities in advancing and disseminating knowledge on digital educational effectiveness in China.

Table 1. presents the most productive affiliations in the field of Digital Tools on Educational Effectiveness.

No	Affiliation	City	Document	Citation
1	Shanghai University	Shanghai	2	230
2	Peking Union Medical College Hospital	Beijing	2	131
3	Beijing Normal University, Beijing	Beijing	6	70
4	Beihang University	Beijing	2	59
5	Guangxi Normal University,	Guilin (Guangxi)	2	53
6	Xi'an Jiatong-Liverpool University	Suzhou	3	40
7	Tongji University	Shanghai	2	27
8	University Of Science Technologi Beijing	Beijing	2	27
9	Chang'an University	Xi'an	2	24
10	Anhui University	Hefei (Anhui)	2	23

Source: Processed data using VOSviewer, 2025

3.5. Document by funding sponsor Digital Tools for Educational Effectiveness in Chinese Higher Education

Based on the graph in Fig. 6 on "Documents by Funding Sponsor," it is evident that research funding for studies on the use of digital tools for educational effectiveness in China is predominantly provided by national and governmental institutions. The National Natural Science Foundation of China stands out as the primary funding sponsor, supporting 16 documents, highlighting its strategic role in advancing research in this area. It is followed by the National Office for Philosophy and Social Sciences, which funded 6 documents, and the Fundamental Research Funds for the Central Universities, which contributed to 5 publications. Other notable funding sources include the Ministry of Education of the People's Republic of China and the National Social Science Fund of China, supporting 4 and 3 documents, respectively. Overall, this funding distribution reflects the strong commitment of the Chinese government and national institutions to fostering interdisciplinary research that integrates digital technology with educational innovation.

Documents by funding sponsor
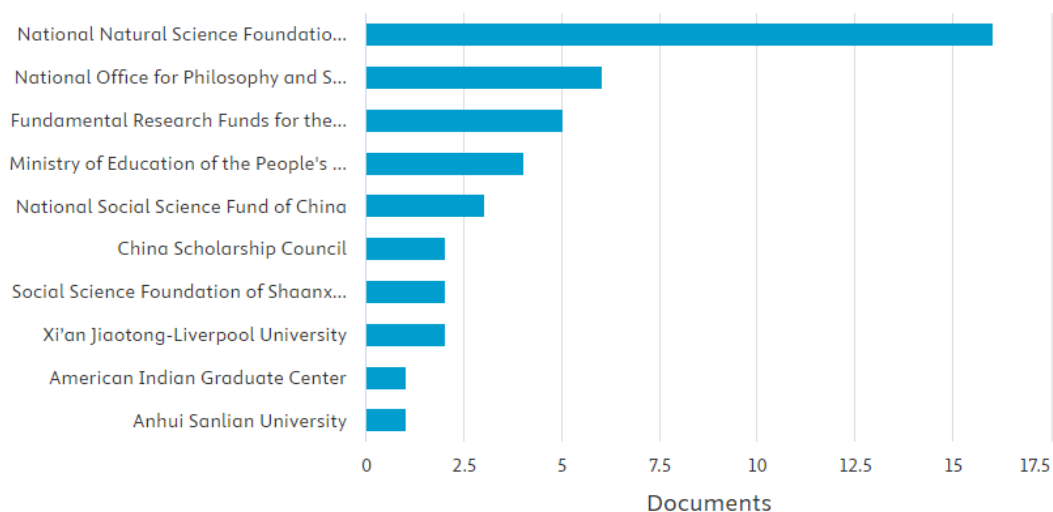
Compare the document counts for up to 15 funding sponsors.

Fig. 6. Document By Funding Sponsor

3.6. Focus Research Digital Tools for Educational Effectiveness in Chinese Higher Education

The researchers also analyzed the research focus and the novelty of keywords using VOSviewer. This analysis aimed to identify current research trends and ensure that the selected keywords accurately reflect recent innovations and developments in the field of digital tools for educational effectiveness in China.

The visualization results indicate that studies on the use of digital tools for enhancing educational effectiveness in China are organized into several interrelated thematic clusters (Fig. 7 and Table 2). The largest cluster, marked in green, includes keywords such as "educational computing," "learning systems," "computer-aided instruction," and "digital transformation," reflecting a strong emphasis on the development of computing-based learning systems. These findings suggest that learning, particularly online learning, requires robust digital infrastructure to improve instructional effectiveness.

The presence of digital tools not only facilitates content delivery but also serves as a crucial support mechanism for creating interactive, structured, and personalized learning experiences [21]. Therefore, the relationship between the use of digital tools and the enhancement of learning quality is

strongly supported by the linkage between educational computing concepts and the design of adaptive, data-driven curriculum strategies.

The blue cluster emphasizes learning support technologies such as "virtual reality," "digital technologies," "online learning," and "digital tools." These findings indicate that the use of digital tools in education can enhance learning processes by making them more immersive, interactive, and contextual. Technologies like virtual reality enable realistic and participatory learning simulations, which are particularly valuable in active and skills-based learning contexts [22]. Meanwhile, online learning and digital platforms provide flexibility for students to access learning materials anytime and anywhere, supporting more personalized and self-directed learning approaches.

The orange cluster is frequently associated with terms such as "artificial intelligence," "digital learning," "ChatGPT," and "digital storytelling," illustrating the integration of artificial intelligence and adaptive digital content into educational processes. This implies that AI technologies, particularly ChatGPT, are significantly transforming the educational landscape by enhancing personalized learning experiences and increasing student engagement [23]. ChatGPT's ability to provide tailored learning guidance, language acquisition support, and creative writing assistance addresses diverse learning needs and fosters the development of 21st-century digital skills [24]. In addition, AI-based tools like ChatGPT facilitate efficient communication, resource integration, and innovative teaching models thus promoting educational equity and lifelong learning [25].

The yellow cluster, which connects machine learning, learning algorithms, and data mining, highlights the crucial role of data analytics in advancing personalized learning. This relationship underscores the application of machine learning to analyze large volumes of educational data, identify patterns in student behavior, preferences, and performance, and tailor learning experiences to meet individual needs [26]. Machine learning algorithms—such as collaborative filtering, content-based filtering, and deep learning—are employed to personalize learning paths and content, thereby improving learning effectiveness [27], [28].

Overall, the keyword map illustrates a growing trend toward a multidisciplinary approach, combining advanced technologies, instructional design, and artificial intelligence to enhance the quality of education.
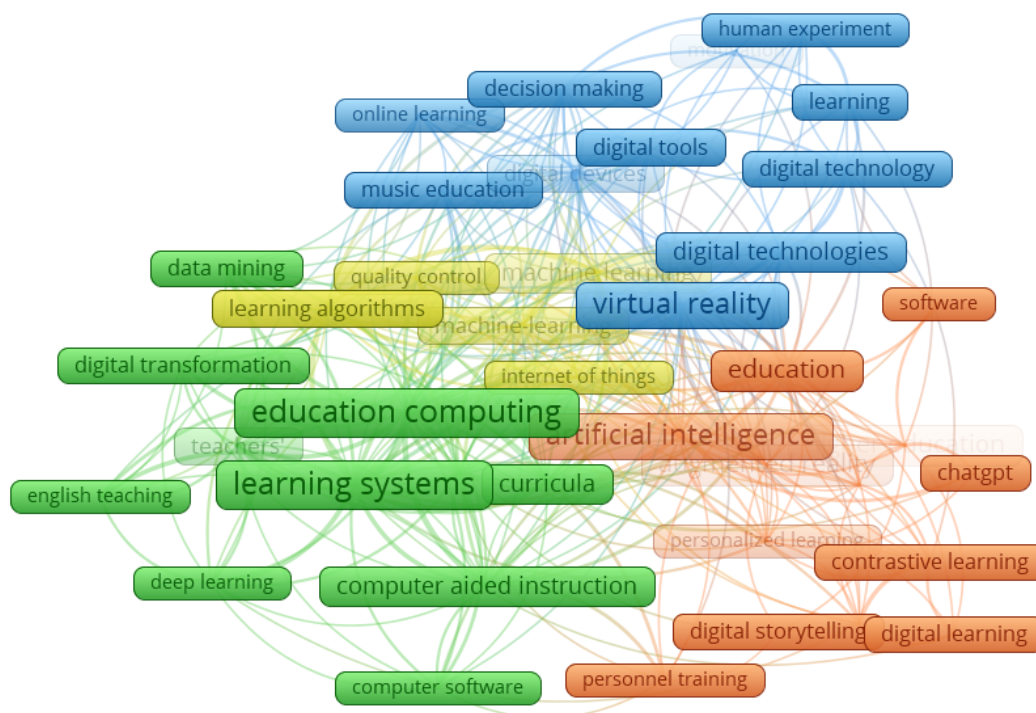

Fig. 7. Visualization of Research Focus

Table 2. Keyword Clustering by Color in The Topic of Educational Effectiveness in Chinese Higher Education

No	Cluster Color	Keywords	Cluster Name
1	Green	Educational Computing, Learning Systems, Computer-Aided Instruction, Digital Transformation, Curricula, English Teaching, Teacher, Computer Software, Deep Learning	Computing-Based Learning System
2	Blue	Virtual Reality, Digital Technologies, Online Learning, Digital Tools, Music Education, Decision Making, Learning, Human Experiment	Immersive and Digital Learning Technologies
3	Orange	Artificial Intelligence, Digital Learning, Chatgpt, Digital Storytelling, Contrastive Learning, Personnel Training, Education	Artificial Intelligence and Adaptive Learning
4	Yellow	machine learning, learning algorithms, data mining, Internet of Thing	Data Analytics and Machine Learning in Education

Source: Visualization generated using VOSviewer

3.7. Keyword Novelty Digital Tools for Educational Effectiveness in Chinese Higher Education

Based on the visualization in Fig. 8, the novelty of keywords in digital tools research is represented by yellow-colored terms, reflecting the latest topical trends as of 2024. Several emerging keywords include ChatGPT, digital storytelling, personalized learning, and digital transformation.

The use of ChatGPT in education has the potential to facilitate access to and understanding of general information; however, it presents limitations in highly specialized knowledge and in applying knowledge to solve complex problems [29]. Furthermore, Dimeli & Kostas (2025), in their review, highlight both the potential and challenges of using ChatGPT in education, including its benefits in fostering critical thinking skills and student engagement, while also emphasizing the importance of ethical oversight and clear guidelines for the use of generative technologies [30].

In addition, digital storytelling serves as an effective digital tool for enhancing student engagement, strengthening conceptual understanding, and encouraging creative expression in higher education. It has been shown to improve the mastery of 21st-century skills such as critical thinking, creativity, and collaboration [31]. Cerero et al. (2025) conclude that digital tools play a significant role in improving learning effectiveness and supporting educational transformation in the digital era [14]. This, in turn, leads to better teaching quality, higher student engagement, and greater efficiency in learning management processes. Moreover, the integration of digital tools enables the creation of more adaptive, collaborative, and data driven learning environments aligned with the demands of 21st-century education.

Kaswan et al. (2024), in their book, discuss the role of personalized learning in smart education, encompassing student modeling and adaptive recommendation systems [32], [33]. This approach not only allows for instruction tailored to individual student needs but also enhances learning engagement and teaching effectiveness through the intelligent, real-time use of data.

These findings reinforce that ChatGPT and similar technologies represent novel keywords with strong potential as future research directions, particularly in the development of adaptive and AI-driven learning systems. The integration of these keywords reflects a paradigm shift in education toward more personalized, intelligent, and responsive models that address the individual needs of learners in the digital transformation era.
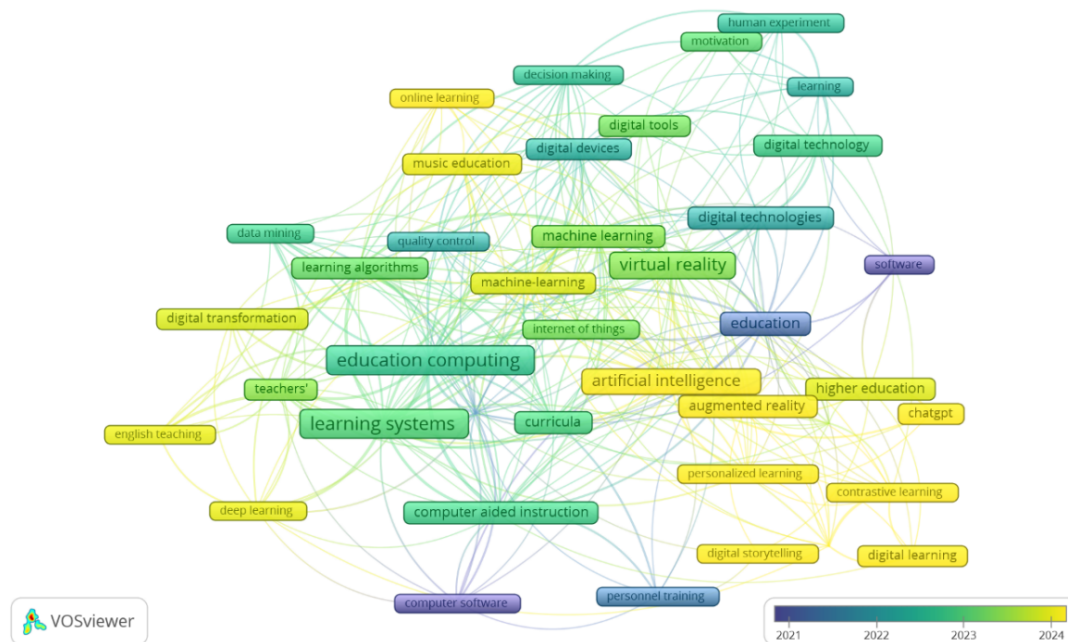
Fig. 8. Visualization of Keyword Novelty

4. Conclusion

This study reveals that the adoption of digital tools in Chinese higher education has experienced rapid growth over the past decade, driven by government policies, research institution support, and multidisciplinary collaboration. The bibliometric analysis highlights that the primary research focuses are on computer-based learning, immersive technologies, artificial intelligence (AI), and machine learning. Emerging tools such as ChatGPT and digital storytelling represent new trends with significant potential to enhance student engagement, personalized learning, and the development of 21st-century skills. Moving forward, the integration of adaptive and data-driven technologies will be key to transforming education. Further research is recommended to explore practical implementations, regional disparities, and the long-term impact of digital tools through qualitative approaches and broader data sources.

Future studies are encouraged to expand the bibliometric analysis by incorporating additional databases such as Web of Science, DOAJ, and Google Scholar to ensure a more comprehensive research scope. Moreover, qualitative or mixed-method approaches can be employed to examine the classroom implementation of digital tools and their direct impact on student engagement and learning outcomes. Follow-up research should also investigate educational policies, institutional readiness, and regional differences in the adoption of digital technologies to ensure more equitable and effective integration across the higher education system.

Declaration

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