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Bibliometric and Visual Insights Into Higher Education Informatization:
A Systematic Review of Research Output, Collaboration, Scope, and Hot Topics

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ABSTRACT

Higher education informatization (HEI) is an interdisciplinary field that examines the use and integration of information and communication technologies (ICTs) in higher education. This paper provides a bibliometric and visual analysis of the research trends, patterns, and topics in this field. Using the Web of Science database, the authors selected and analyzed 199 SCI and SSCI papers on HEI published from 2000 to 2023 by VOSviewer and CiteSpace software. The results indicate that the publication volume of HEI research has grown significantly in recent years. The author network shows the collaboration and contribution of different researchers and institutions, while the journal network reveals the multidisciplinary nature and scope of the field. The keyword network and the burst keyword analysis identify the main research themes and the emerging hot topics in HEI. The co-citation network of sources illustrates the theoretical and methodological foundations and influences of the field. The paper concludes with some implications and suggestions for future HEI research.

KEYWORDS

Bibliometric Analysis, E-Learning, Higher Education Informatization, Motivation

With the emergence of new technologies and new means, such as artificial intelligence, big data, cloud computing, and mobile learning (Halili, 2019), higher education informatization has achieved new growth and breakthroughs in recent years. These technologies have facilitated the development of smart education (Peng et al., 2019), which offers personalized, adaptive, and intelligent learning environments and services (Sousa-Vieira et al., 2022). Various fields of higher education have benefited from the application and impact of these technologies, such as curriculum design (E. H. Fedorenko et al., 2019; E. G. Fedorenko et al., 2023), teaching evaluation (Liang et al., 2021), student engagement (Alkorashy & Alotaibi, 2023; Kahu, 2013), academic performance (Liu & Zhao, 2018), and learning analytics (Veluri et al., 2022; Salas-Pilco et al., 2022).

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However, higher education informatization also encounters new challenges and opportunities (Mynbayeva & Anarbek, 2016), especially in the post-epidemic era, when online and hybrid learning modes have become more common and necessary (Zhang et al., 2023). The COVID-19 pandemic has revealed the gaps and weaknesses in the current higher education informatization systems and practices (Turnbull et al., 2021), such as the lack of infrastructure, resources, skills, and policies. Meanwhile, the pandemic has also stimulated the innovation and transformation of higher education informatization (Tejedor et al., 2021), such as the emergence of new pedagogies, platforms, and partnerships. Therefore, a review of higher education informatization is timely and relevant, to understand its current state, trends, and issues.

This paper aims to provide a comprehensive and systematic review of higher education informatization research, using bibliometric visualization methods. Bibliometric visualization is a technique that analyzes and displays the information and relationships of scientific publications, such as citation data, bibliographic metadata, and article content (Moral-Muñoz et al., 2020), using statistics and graphics. This paper applies bibliometric visualization methods to map the landscape of higher education informatization research, and to identify the key authors, journals, countries, keywords, and themes in this field. This paper also reveals the interdisciplinary nature of higher education informatization, as it involves various disciplines such as computer science, engineering, education, and psychology. This paper hopes to contribute to the advancement of higher education informatization research and practice, by providing a comprehensive overview, a critical evaluation, and a future outlook of this field.

METHODS AND DATA

Research Methods

Bibliometrics is a discipline that uses quantitative methods to analyze and evaluate various aspects of scholarly literature (Ellegaard & Wallin, 2015), which originated in the late 19th century (Lawani, 1981). It mainly includes citation-based analysis and science mapping (Braam & Moed, 1991). These methods enable researchers to measure the impact of their work, compare it with others, and identify influential papers within a specific field (Li et al., 2020). When applied to the higher education informatization research, bibliometrics can provide objective, transparent, and cost-effective measurements of research impact. Moreover, it helps to visualize the evolution of the research field.

This study employs CiteSpace and VOSviewer to construct the bibliometric knowledge graph. CiteSpace is particularly good at detecting patterns and trends in literature (Chen, 2006). It offers a variety of functions to facilitate the understanding and interpretation of network patterns and historical trends. Alternatively, VOSviewer focuses on the graphical representation of bibliometric maps (Van Eck & Waltman, 2010). It is especially useful for analyzing large data sets, as it can process millions of records and offer a range of advanced features, such as a cluster detection and a visualization of temporal trends.

In conclusion, both CiteSpace and VOSviewer have unique capabilities that make them valuable tools for bibliometric research and knowledge graph construction. They enable the researchers to visualize complex bibliometric data in a meaningful and interpretable way.

Data Sources and Screening

We used the Web of Science (core collection) as our main data source, as it ensures the comprehensiveness and reliability of the data analyzed. The indices selected were SSCI and SCI-Expanded. Our search strategy incorporated the following terms:

TS=((“Higher Education” OR “College” OR “University”) AND (“Informatization” OR “Office Automation”) AND (“E-Learning” OR “Mobile Learning”) OR (“Administration” OR “Management” OR “Supervision”))

The search covered the period from January 1, 2000 to December 1, 2023, yielding a total of 2,950,001 literature records. Next, we refined our search by selecting ‘Article’ as the document type, which yielded 2,336,821 articles. Further refinement was achieved by screening the Web of Science categories and Citation Topics, leading to a selection of 2,355 articles.

However, the data obtained directly from the search formula may contain duplications or inconsistencies with the topic (Martín-Martín et al., 2018). Therefore, we performed a pre-processing step before the analysis, which involved a manual review of each article’s content (including the title and abstract) to eliminate redundant and irrelevant publications, ensuring that the selected articles were indeed related to higher education informatization research. After this rigorous screening process, we retained 199 articles for content and bibliometric mapping analysis (see Figure 1).

DESCRIPTIVE STATISTICS

Analysis of Publication Volume

The study incorporates 199 papers, contributed by 565 authors hailing from 295 organizations across 53 countries. These papers, published in 65 different journals, have garnered 8,620 citations from 5,183 journals.

Figure 1. Paper Screening and Data Cleaning Process Flowchart

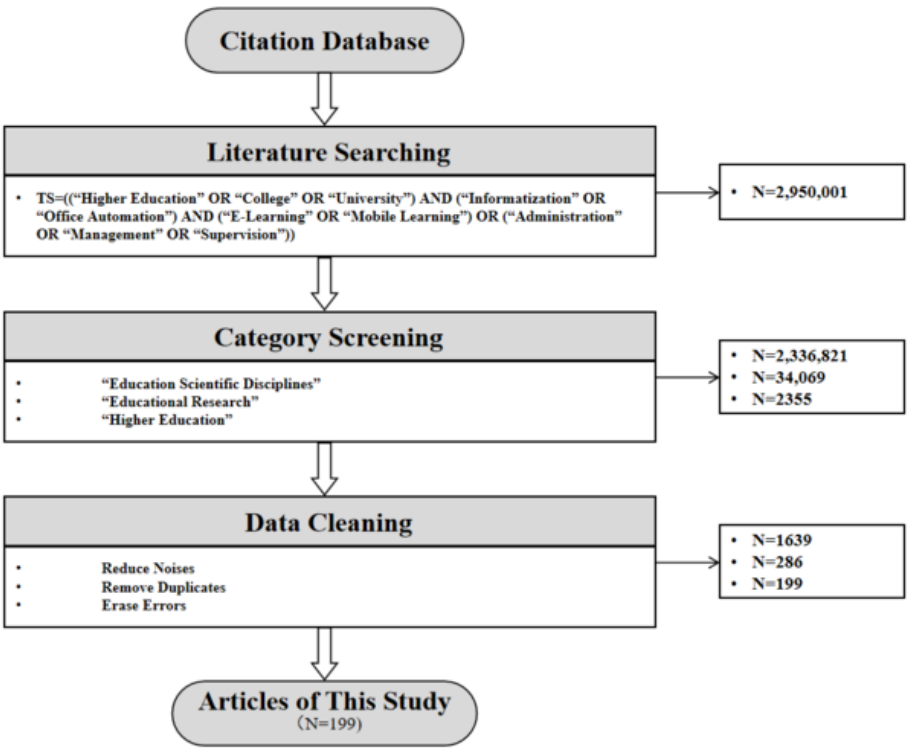


Figure 2 illustrates the annual distribution of published papers in the field of higher education informatization research from 2000 to 2023, based on data from the Web of Science. The x-axis denotes the year, while the y-axis signifies the number of papers published. The blue line represents the actual number of papers published, and the black dotted line symbolizes the trend line of the number of papers over the years, exhibiting a positive and linear relationship. The trend line reveals an increasing number of published papers over the years, with a slight dip observed in the middle. The R-squared value of 0.7709 suggests that the trend line fits the data well.

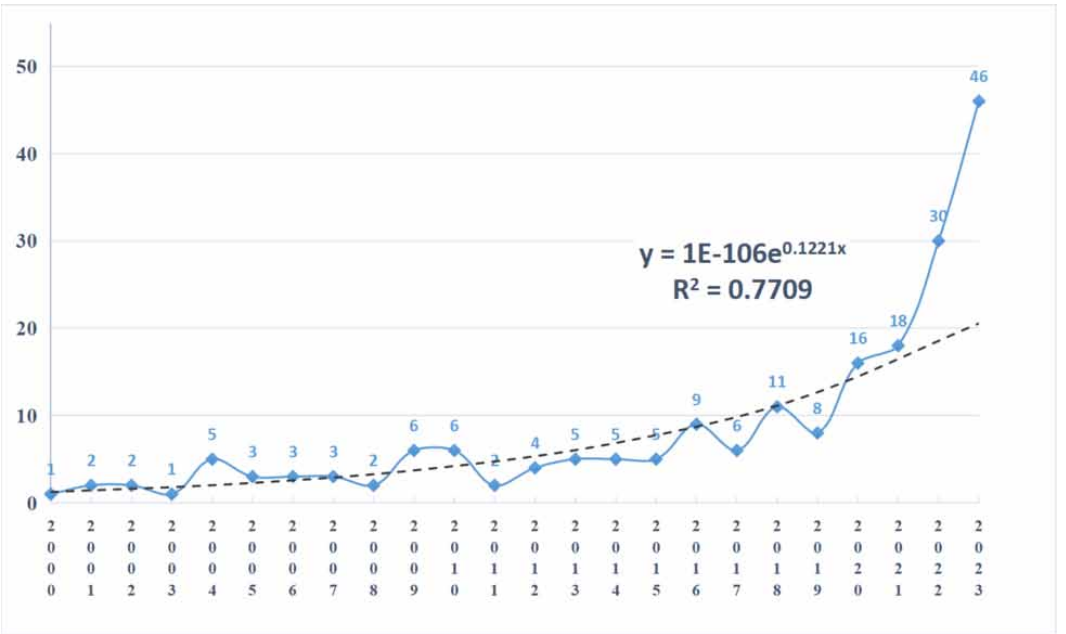
The figure underscores that the field of higher education informatization research has witnessed a significant surge in the number of published papers In the new century, escalating from a solitary paper in 2000 to nearly 50 papers in 2023. This surge mirrors the growing attention and interest of researchers and practitioners in this field, as well as the swift development and innovation of the related theories and methods.

Analysis of the Author

Bibliometric analysis of authorship is a technique employed to examine the productivity, impact, collaboration, and research topics of authors in a specific field or discipline (Donthu et al., 2021). It aids in identifying the most influential and prolific authors, their co-authorship networks and patterns, their research interests and themes, and their citation performance and role in the field. Price proposed that half of the papers on a given topic are authored by a group of highly productive authors, and this collection of authors is numerically equivalent to the square root of the total number of all authors (Milojević, 2012).

$$\sum_{m+I}^{I} n\left(x\right) = \sqrt{N} \tag{1}$$

Figure 2. Literature on Higher Education Informatization Research (2000-2023)



In equation (1), n(x) signifies the number of authors who have authored x papers, $I = n_{max}$ represents the number of papers by the most prolific authors in the field ($n_{max} = 5$ here), N is the total number of authors, and m is the minimum number of publications by core authors. According to Price's Law, the minimum number of publications by core authors in a field:

$$m = 0.749 \times \sqrt{n_{\max}} \tag{2}$$

Here, m≈1.675, so authors with more than 2 publications (including 2) are considered as core authors in the field. Upon analyzing the 199 papers referenced in the text, a total of 76 core authors have published 103 papers, accounting for 51.76% of the total number of papers, thereby meeting the 50% standard proposed by Price. This suggests the formation of a relatively stable author collaboration group in the field of higher education informatization research.

Table 1 showcases the top 10 scholars in the realm of higher education informatization research, ranked by their productivity and impact. This information is derived from VOSviewer.

The most productive author is Kinshuk, who has published five documents and received 271 citations, with an average citation per publication of 54.20. He is a professor of learning technologies at the University of North Texas, USA, and his research interests include smart learning environments (Kinshuk et al., 2016), adaptive and personalized learning (Kinshuk, 2014), and mobile and ubiquitous learning (Kinshuk & Jesse, 2013). The author with the highest average citation per publication and the most cited is S. Graf, who has published two documents and received 153 citations, with an average citation per publication of 76.50. She is an associate professor of computing and information systems at Athabasca University, Canada, and she has published high-quality and high-impact papers on topics such as adaptive and personalized learning, learning analytics (Graf & Kinshuk, 2007), and artificial intelligence in education (Graf et al., 2010).

In essence, the top 10 authors demonstrate diverse levels of productivity and influence in the field of higher education informatization. Kinshuk and Graf are particularly noteworthy contributors, with Kinshuk leading in terms of productivity. Authors with fewer publications prove that significant impact can be achieved through focused and substantial contributions, as reflected in their average citation/publication ratios. The varied characteristics of these authors add to the richness and multidimensionality of research in higher education informatization.

Table 1. Top Authors in Higher Education Informatization Research

Rank	Author	Documents	Citations	Average Citation/Document
1	kinshuk	5	271	54.20
2	martin,florence	4	42	10.50
3	sinclair,a.john	3	71	23.67
4	chang,yi-chun	3	107	35.67
5	chu,chih-ping	2	107	53.50
6	graf,sabine	2	153	76.50
7	moyer,joanne m.	2	29	14.50
8	ritzhaupt,albert d.	2	42	21.00
9	altun,arif	2	16	8.00
10	diaz-pérez,p	2	15	7.50

Analysis of the Journals

The quantity of journal publications serves as a measure of the productivity and output of a field, journal, author, or topic (Yu, 2022). It also provides insights into the activity and dynamism of a field, the popularity and influence of a journal, the productivity and prominence of an author, and the relevance and appeal of a topic (Razmjooei et al., 2023).

Table 2 enumerates the top 10 sources that have contributed the most to the field of higher education informatization research, detailing their document count, citation count, and average citation per document. The top 10 journals have collectively published 111 documents and garnered 1,416 citations in the field of higher education informatization, averaging 12.76 citations per document. This underscores the high productivity and impact of these journals in this field.

Education and Information Technologies emerges as the most productive journal with 32 publications and 130 citations, averaging 4.06 citations per publication. This journal, the official journal of the International Federation for Information Processing Technical Committee on Education, explores the intricate relationships between information and communication technologies and education.

Educational Technology & Society, the most cited journal, has published 24 documents and received 551 citations, averaging 22.96 citations per publication. This quarterly academic journal in educational technology addresses issues pertinent to the developers of educational systems and educators who implement and manage such systems.

Journal of Computer Assisted Learning, which has the highest average citation per publication, has published four documents and received 140 citations, averaging 35.00 citations per publication. This international peer-reviewed journal covers the entire spectrum of uses of information and communication technology to support learning and knowledge exchange.

The journals with the lowest average citation per publication are *Journal of Hospitality Leisure Sport & Tourism Education* and *Studies in Continuing Education*, each having published four documents and received six and 11 citations, respectively, averaging 1.50 and 2.75 citations per publication, respectively. While these journals are related to the field of education, their scope is more specific and narrow compared to the other journals, and they may cater to a smaller and less active audience.

Table 2. Key Journals in Higher Education Informatization Research

Rank	Source	Publications	Citations	Average Citation/ Publication
1	education and information technologies	32	130	4.06
2	educational technology &society	24	551	22.96
3	british journal of educational technology	12	123	10.25
4	computers &education	9	290	32.22
5	interactive learning environments	9	46	5.11
6	etr&d-educational technology research and development	8	103	12.88
7	international journal of management education	5	16	3.20
8	journal of computer assisted learning	4	140	35.00
9	journal of hospitality leisure sport &tourism education	4	6	1.50
10	studies in continuing education	4	11	2.75

The top 10 journals exhibit varying levels of productivity, impact, and quality, as evidenced by their differing document counts, citation counts, and average citation per document. The table also reveals the diverse disciplinary backgrounds of the journals, spanning fields such as education, computer science, information technology, management, hospitality, leisure, sport, and tourism. This underscores the interdisciplinary and cross-disciplinary nature of higher education informatization.

VISUAL ANALYSIS AND DISCUSSION

Visual Analysis of the Countries

Bibliometric research allows for the exploration of the geographical distribution and diversity of research activities and outputs within a specific field or topic (Merigó et al., 2016). This approach facilitates an understanding of regional disparities, commonalities, and collaborations in terms of research productivity, impact, quality, and specialization. Moreover, it aids in identifying the leading, emerging, and underrepresented nations within a field or topic (Baek & Doleck, 2022).

Table 3 lists the top 10 countries with the highest number of publications in this area. The People's Republic of China stands out as the most productive country with the highest average citation per publication. With 40 documents published and 634 citations received, resulting in total link strength of 1,430, it is evident that China is a leading and active contributor in the field of higher education informatization, boasting a significant number of researchers and publications on this topic.

The United States, on the other hand, is the most cited country. With 26 documents published and 220 citations received, resulting in total link strength of 973, it is clear that the United States holds a position of influence and authority in the field of higher education informatization, as evidenced by the high impact and recognition of its publications on this topic.

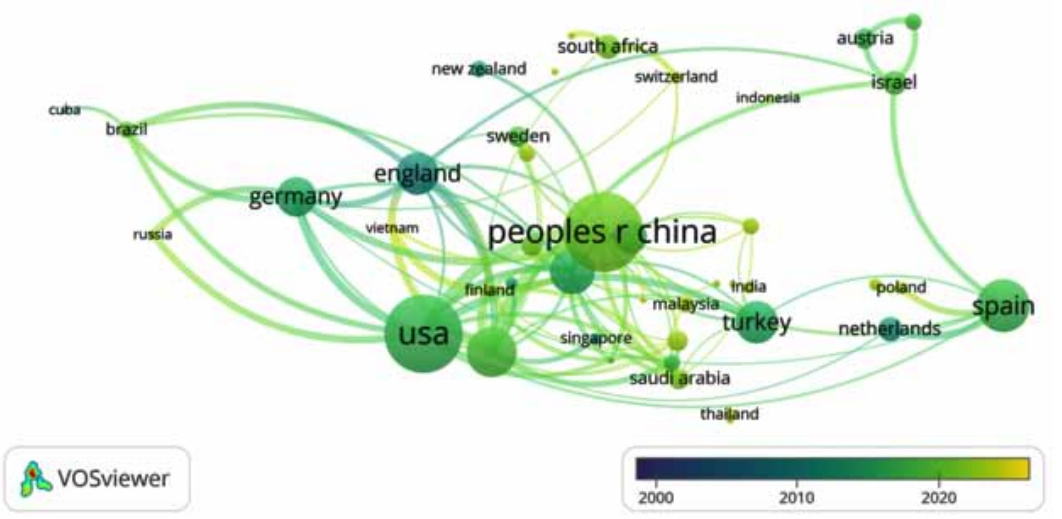
The geographical distribution of the top 10 countries in this study spans various continents and regions, including Asia, Europe, North America, and Oceania. This diversity underscores the global and cross-cultural nature of higher education informatization research, suggesting that different countries and regions may offer unique perspectives and experiences on this topic.

Figure 3, a network visualization generated using VOSviewer data, illustrates the countries that have contributed academic papers on higher education informatization. The graph reveals that 52 countries have published papers on this topic, each demonstrating varying degrees of productivity, collaboration, and recency.

Table 3. Leading Countries in Higher Education Informatization Research

Rank	Country	Document	Citation	Total Link Strength
1	peoples r china	40	634	1430
2	US	26	220	973
3	spain	15	104	339
4	australia	14	74	956
5	canada	12	45	658
6	englan	11	256	620
7	turkey	11	80	226
8	germany	10	96	544
9	greece	8	152	164
10	israe	5	30	308

Figure 3. Countries Overlay Visualization in Higher Education Informatization Research



China, represented by the largest circle, is the most productive country with 40 papers on higher education informatization. The United States, depicted by the second-largest circle, is the most cited country with 220 citations for its 26 papers on this topic. The thickest line connecting China and the United States indicates their status as the most collaborative countries, having co-authored 12 papers on higher education informatization. Spain, connected to China by the second thickest line, ranks as the second most collaborative country, having co-authored nine papers on this topic with China.

In terms of recency, Israel, represented by the most yellow circle, is the most recent country with an average publication year of 2020.5 for its five papers on higher education informatization. Canada, depicted by the second most yellow circle, is the second most recent country with an average publication year of 2020.3 for its 12 papers on this topic. Conversely, Greece, represented by the bluest circle, is the oldest country with an average publication year of 2017.1 for its eight papers on higher education informatization. Turkey, depicted by the second bluest circle, is the second oldest country with an average publication year of 2017.3 for its 11 papers on this topic.

Visual Analysis of Keywords

Bibliometric analysis of author-assigned keywords offers a method for examining the frequency, co-occurrence, and evolution of keywords within a specific field or discipline (Tripathi, et al., 2018). This approach can provide valuable insights for various stakeholders, including researchers, editors, reviewers, funders, and policymakers, enabling them to understand the current state and trends of a field, identify potential research gaps and opportunities, evaluate the quality and impact of their keywords, and make strategic decisions for the field's development (Donthu et al., 2021).

Table 4 presents the top 10 author keywords used in papers on higher education informatization, as per VOSviewer data. The table reveals that:

The author keywords in higher education informatization research encapsulate the key topics, themes, and issues pertinent to the field. These include the influence of technology, the challenges and opportunities presented by online and hybrid education, the quality and effectiveness of instruction and learning, and the evolving requirements of work and society. The author keywords are dynamic and evolve over time, reflecting emerging trends and developments in the field, such as the COVID-19 pandemic, advancements in artificial intelligence, and innovations in learning analytics. This suggests

Table 4. Prominent Author Keywords in Higher Education Informatization Research

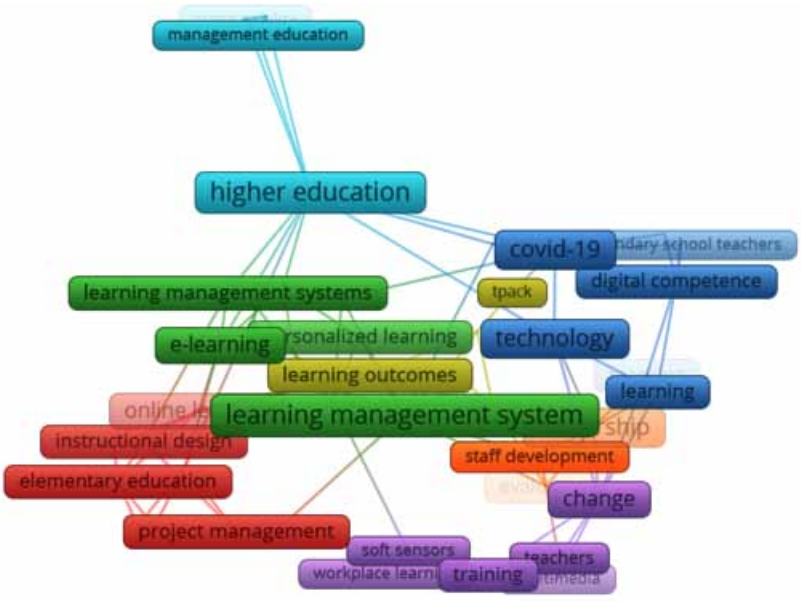
Rank	Author Keyword	Occurrences	Total Link Strength
1	higher education	11	10
2	learning management system	9	14
3	covid-19	9	9
4	e-learning	9	8
5	learning management systems	7	8
6	learning styles	7	6
7	workplace learning	7	3
8	instructional design	6	5
9	adaptive learning	5	7
10	online learning	5	7

that higher education informatization is a progressive and adaptive field aiming to enhance and transform education and society.

Figure 4 provides a network visualization of author keywords in higher education informatization research. It displays the results of clustering the 46 author keywords that appear more than three times in the papers on higher education informatization, based on VOSviewer data. The graph indicates that the author keywords can be categorized into seven clusters, each representing a different aspect or theme of higher education informatization. The clusters are as follows:

Cluster 1 (nine items): This cluster encompasses author keywords associated with the design and implementation of online learning across various educational contexts and disciplines.

Figure 4. Author Keyword Network Visualization in Higher Education Informatization Research



Keywords include collaborative learning, distance education, elementary education, engineering education, instructional design, project management, and teaching/learning strategies. This cluster underscores the diversity and complexity of online learning in higher education informatization, as well as the pedagogical and managerial challenges and opportunities it presents.

Cluster 2 (nine items): This group encompasses keywords from authors that pertain to the utilization and evolution of learning management systems (LMS) and virtual learning environments (VLE) in the context of higher education informatization. Keywords such as e-learning, LMS, Moodle, and VLE are included. Additionally, this group contains keywords related to the customization and adaptability of learning, including adaptive learning, distance learning, learning styles, and personalized learning. This group underscores the significance and novelty of LMS and VLE in higher education informatization, as well as the potential for and necessity of adaptive and personalized learning.

Cluster 3 (eight items): This group includes keywords from authors that discuss the effects of COVID-19 on higher education informatization and the subsequent responses, with keywords like COVID-19, online education, teacher training, and technology. It also contains keywords about the digital competence and literacy of teachers and learners, such as digital competence, learning, secondary school teachers, and teaching. This group highlights the challenges and opportunities presented by COVID-19 for higher education informatization, as well as the skills and knowledge needed by teachers and learners.

Cluster 4 (seven items): This group includes keywords from authors that relate to the application and integration of artificial intelligence (AI) and machine learning in higher education informatization, with keywords like AI, machine learning, and learning analytics. It also includes keywords about the evaluation and assurance of learning outcomes and quality, such as educational technology, learning outcomes, quality assurance, and self-directed learning. This group reflects how AI and machine learning are advancing and transforming higher education informatization, as well as how learning outcomes and quality are being assessed and improved.

Cluster 5 (six items): This group includes keywords from authors that relate to the changes and innovations in multimedia and soft sensors in higher education informatization, with keywords like change, multimedia, and soft sensors. It also includes keywords about the training and development of teachers and workers, such as teachers, training, and workplace learning. This group reflects the innovation and development of multimedia and soft sensors in higher education informatization, as well as the training and development of teachers and workers.

Cluster 6 (four items): This group includes keywords from authors that discuss the sustainability and transformation of higher education informatization, with keywords such as higher education, management education, sustainability, and transformative learning. This group highlights the sustainable transformation of higher education informatization and its management and leadership aspects.

Cluster 7 (three items): This group includes keywords from authors that focus on the evaluation and leadership of staff development in higher education informatization, with keywords like evaluation, leadership, and staff development. This group emphasizes the evaluation and leadership aspects of staff development in higher education informatization, as well as staff empowerment.

Co-Citation Analysis of Sources

Co-citation analysis, a bibliometric method, gauges the similarity and relationship between two sources based on their co-citation frequency and strength (Kleminski et al., 2022). This technique aids in pinpointing influential and pertinent sources within a research domain, mapping the field's intellectual structure and evolution (Nerur et al., 2008). Additionally, it facilitates the discovery of research themes, clusters, and fronts, and uncovers the links and gaps among different areas (Boyack & Klavans, 2010).

In our research, we employed VOSviewer to construct a co-citation map of journals, setting the minimum co-citation frequency threshold at 10. This resulted in the inclusion of 89 journals for the co-citation analysis. The three most frequently cited journals were *Comput Educ* (335 papers), *Comput Hum Behav* (109 papers), and *Educ Inf Technol* (105 papers).

Figures 5 and 6 depict the Network Visualization and Density Visualization Map of Co-Citation Sources on Higher Education Informatization Research, respectively. These figures present the same co-citation data of the journals in the field of higher education informatization in two distinct ways, utilizing different visual elements and indicators. The density visualization illustrates the distribution and concentration of the co-citation links among the journals, using varying colors and shades. Conversely, the network visualization displays the co-citation links' network and structure among the journals, using different shapes and sizes. Both visualizations reveal the same six clusters of journals, each representing a unique aspect or theme of higher education informatization, albeit with varying levels of detail and labels. The clusters are:

Cluster 1 (17 items): This cluster encompasses sources related to the general and interdisciplinary aspects of higher education, such as higher education, adult education, lifelong education, management education, sustainability, and transformative learning. It mirrors the wide-ranging and diverse scope and context of higher education informatization, along with the social and environmental issues and implications involved.

Cluster 2 (15 items): This cluster comprises sources related to the online and distance learning modes and technologies of higher education informatization, such as e-learning, learning management systems, online learning, distance education, and internet and higher education. It reflects the prevalent modes and technologies of higher education informatization, as well as the pedagogical and technical challenges and opportunities involved.

Figure 5. Co-Citation Sources Network Visualization in Higher Education Informatization Research

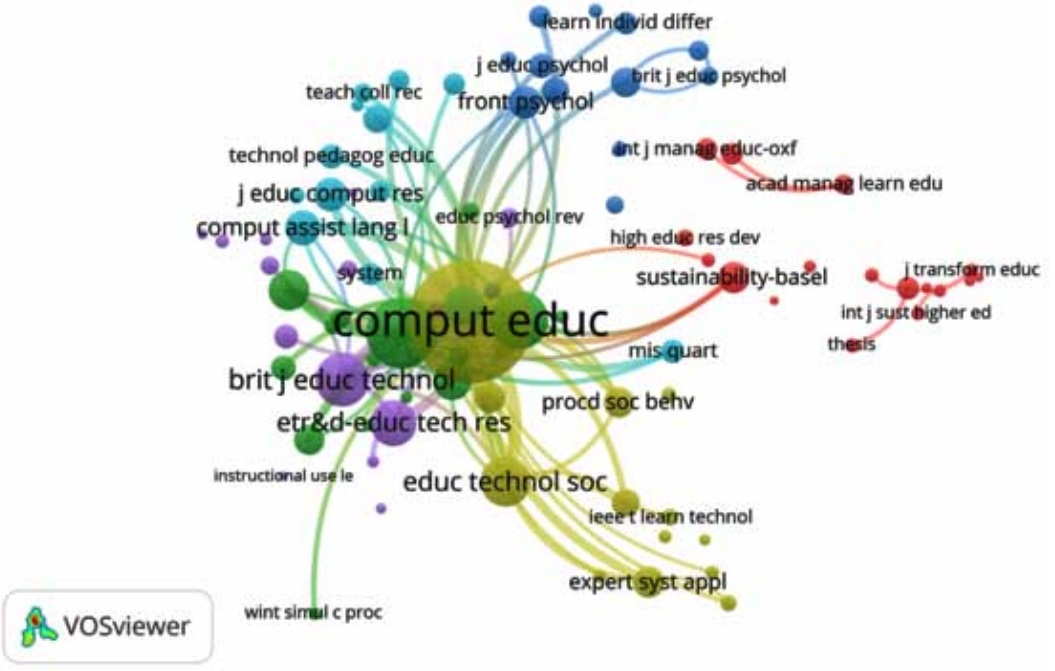
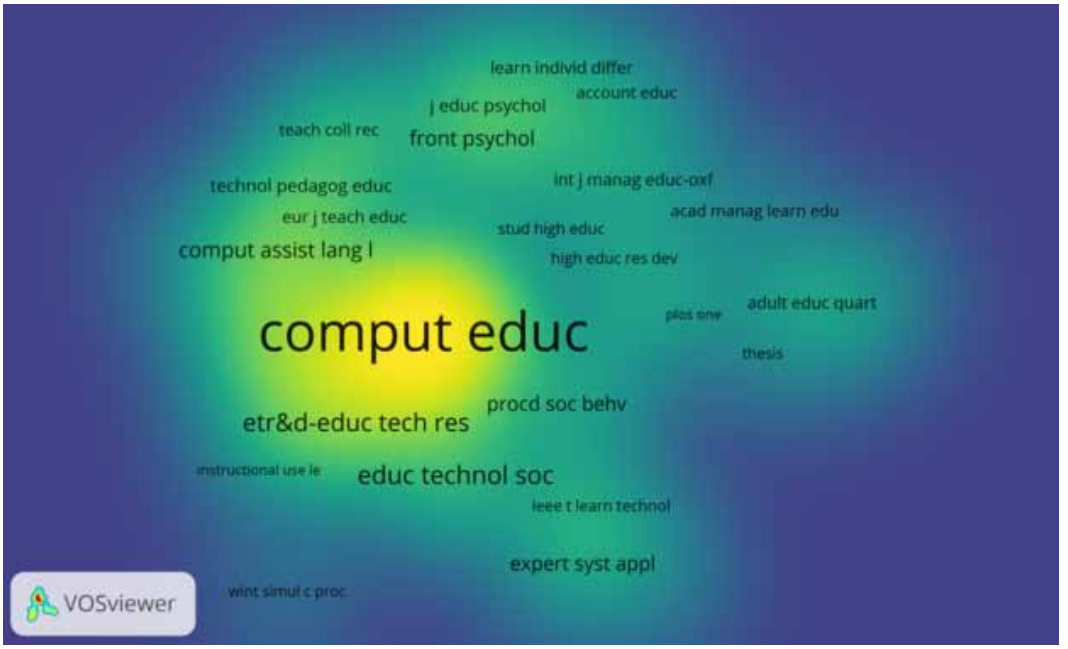


Figure 6. Co-Citation Sources Density Visualization in Higher Education Informatization Research



Cluster 3 (14 items): This cluster comprises sources that delve into the educational and psychological facets of higher education informatization, such as education, psychology, learning, teaching, instruction, and evaluation. It mirrors the fundamental aspects of higher education informatization and the cognitive and affective factors and outcomes involved.

Cluster 4 (14 items): This cluster encompasses sources that explore the computer science and engineering dimensions of higher education informatization, such as computer science, engineering, artificial intelligence, machine learning, and computer education. It reflects the advanced and innovative aspects of higher education informatization and the scientific and technological methods and applications involved.

Cluster 5 (14 items): This cluster includes sources that focus on the media and communication aspects of higher education informatization, such as media, communication, technology, information, and digital literacy. It mirrors the media and communication aspects of higher education informatization and the information and communication skills and competencies involved.

Cluster 6 (13 items): This cluster comprises sources that concentrate on the specific and regional aspects of higher education informatization, such as Asia-Pacific, language, nursing, system, and vocational learning. It reflects the specific and regional aspects of higher education informatization and the cultural and contextual differences and similarities involved.

Visual Analysis of Burst Keyword

Burst keywords in bibliometrics denote the abrupt and temporary surge in the occurrence frequency of specific terms or keywords in scholarly literature within a defined period (Boyack & Klavans, 2010). This analysis aids in detecting emerging topics, trends, and frontiers in a research field (Tang et al., 2018), and in revealing shifts in research focus and interest over time (Xu et al., 2021).

In our study, we utilized the burst keywords function of CiteSpace to extract the burst words in this research field. Nine burst keywords were identified, as depicted in Figure 7. The figure conveys the following information:

Figure 7. Top Keywords With the Strongest Citation Bursts on Higher Education Informatization Research

The earliest burst keyword, knowledge management, began to surge in frequency in 2003 and ceased in 2006, with a strength of 2.2372. This suggests that knowledge management was a burgeoning and trending topic in the early stage of higher education informatization, referring to the process of creating, sharing, and applying knowledge in higher education institutions and practices.

The most recent burst keyword, styles, began to surge in frequency in 2021 and is still ongoing, with a strength of 2.057. This suggests that styles is a burgeoning and trending topic in the current stage of higher education informatization, referring to the different preferences and approaches of learners and educators in higher education informatization.

The strongest burst keyword, higher education, began to surge in frequency in 2018 and is still ongoing, with a strength of 3.6925. This suggests that higher education is a burgeoning and trending topic in the current stage of higher education informatization, referring to the level of education that is most affected and transformed by information and communication technologies.

The weakest burst keyword, culture, began to surge in frequency in 2013 and ceased in 2016, with a strength of 1.7431. This suggests that culture was a burgeoning and trending topic in the middle stage of higher education informatization, referring to the social and cultural factors and implications of higher education informatization.

The burst keyword analysis of the papers on higher education informatization can aid in understanding the evolution and development of the research field, as well as in identifying the hot and novel topics and issues in the research field. The burst keyword analysis can also guide the current and future research directions and priorities in the research field, as well as inspire new and innovative ideas and solutions in the research field.

CONCLUSION AND PROSPECTS

The dynamic and evolving field of higher education informatization (HEI) is a response to the digital era's opportunities and challenges. It holds significant implications for higher education's development, innovation, and knowledge dissemination. Despite its growing importance, comprehensive and systematic studies providing an overview and insight into HEI research's current state and future direction are scarce. This paper addresses this gap by conducting a bibliometric and visual analysis of 199 SCI and SSCI papers on HEI published from 2000 to 2023, using the Web of Science database and VOSviewer and CiteSpace software. The contributions of this paper to the HEI literature are as follows:

- There has been a significant increase in the volume of HEI research publications in recent years, particularly since 2018, indicating the field's growing importance.
- China and the United States are leading in HEI research productivity and influence, followed by Spain, Australia, and Canada. The network of countries reveals the collaboration and competition among different regions and continents.

- A stable group of collaborating authors has emerged in HEI. The network of authors identifies the leading and emerging scholars and institutions in HEI research, along with the patterns and clusters of co-authorship. The most prolific and cited authors include Kinshuk, Martin, Sinclair, and Chang.
- The network of journals demonstrates the multidisciplinary nature and scope of HEI research, encompassing disciplines such as education, computer science, information science, and management. The most active and prestigious journals include *Education and Information Technologies*, *Educational Technology & Society*, and the *British Journal of Educational Technology*.
- The analysis of author keywords and burst keywords identifies the main research themes and emerging hot topics in HEI research, such as online learning, big data, and artificial intelligence. The network of keywords also shows the evolution and transition of research topics over time, reflecting the changing needs and challenges of higher education in the digital era.
- The co-citation network of sources illustrates the theoretical and methodological foundations and influences of HEI research, highlighting the key sources that shape the field. The most cited and influential sources include papers from *Comput Educ* (335 papers), *Comput Hum Behav* (109 papers), and *Educ Inf Technol* (105 papers).

Based on these findings, we can infer that current research on higher education informatization primarily focuses on the application of emerging technologies, such as artificial intelligence, to enhance teaching and learning outcomes and experiences. Despite this focus, the field also presents certain deficiencies and limitations:

- There is a noticeable lack of diversity and inclusivity in research perspectives and contexts. A majority of papers in this field originate from developed countries, particularly the United States, China, and Europe, reflecting their specific educational systems, policies, and cultures. There is a pressing need for increased research from developing countries, especially those in Africa, Latin America, and Asia, to address the unique challenges and opportunities of higher education informatization within diverse socio-economic and cultural settings.
- The field is characterized by a lack of interdisciplinary and collaborative research approaches and methods. Most papers are from the disciplines of education, computer science, and medicine, employing quantitative and descriptive methods such as surveys, experiments, and case studies. There is a need for more research from other disciplines like sociology, psychology, and philosophy, utilizing qualitative and critical methods such as interviews, ethnography, and discourse analysis. This would allow for a deeper and broader exploration of the implications and impacts of higher education informatization on society, culture, and ethics.
- There is a lack of empirical and longitudinal research evidence and evaluation. Most papers in this field are based on theoretical and conceptual frameworks and report the results and findings of short-term and small-scale interventions and projects. More research is needed that is based on empirical and longitudinal data, reporting the outcomes and effects of long-term and large-scale implementations and policies of higher education informatization on students, teachers, institutions, and stakeholders.

Therefore, some possible directions for further research in this field are:

- Comparative and cross-cultural studies on higher education informatization in different regions and countries should be conducted to identify best practices and lessons learned from various contexts and experiences.

- Interdisciplinary and collaborative research frameworks and methods should be adopted, engaging with different perspectives and stakeholders in higher education informatization, such as students, teachers, administrators, policymakers, and researchers.
- Empirical and longitudinal data on higher education informatization should be collected and analyzed to evaluate and monitor the effectiveness and impact of higher education informatization on the quality, equity, and innovation of higher education.

AUTHOR CONTRIBUTIONS

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DATA AVAILABILITY STATEMENT

The raw data presented in this study are openly available at https://www.webofscience.com, accessed on December 11, 2023. The other data used to support the findings of the study are available from the author upon request. The author's email address is duanyushi2023@163.com.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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