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Article

Mapping and visualization of literature in distance education: A scientometric analysis based on citespace

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Abstract: Distance education (DE) has recently become a noteworthy study topic in the public education system. From the Web of Science database, 5719 articles discussing DE and published in the period of 2011–2023 were acquired. By analyzing the overall characteristics, co-citation, and keyword co-occurrence of the selected articles, which utilized Cite Space software, the history of DE could be systematically grasped, thereby reasonably predict the emphases of future development. We found that the number of papers relevant to DE had been rapidly growing since 2018. USA, China, and Turkey are the top three countries where most authors or teams were located. The map of keyword cooccurrence showed that the previous DE research mainly focused on telelearning, adult learning, and distributed learning environment. The recent burst words emerging are used to determine that distance education will continue to be studied in the field with high explosive keywords such as visual tracking, technology acceptance model, and user interface. This will provide suggestions and directions for the development of distance education.

Keywords: distance education; citespace; interaction; design; user interface

1. Introduction

Distance education (DE) has continually developing definitions in the minds of the public, which rely at least partially on the technological innovations promoting the generation change of delivery methods. In 2011, Moore declared the definition of DE as "teaching and planned learning in which teaching normally occurs in a different place from learning, requiring communication through technologies as well as special institutional organization" (Moore and Kearsley, 2011). In recent years, towards the improvement of DE delivery, the introduction of modern technologies has resulted in increasingly remarkable contributions, such as websites, podcasts, mobile apps, interactive tutorials, video conferences, as well as virtual environments (Safapour et al., 2019). Especially, based on broadly applying the Internet and online tools to enhance the efficiency of social communication, online DE has remarkably contributed to the public education by endowing the courses with sufficient flexibility. Since the outbreaks of the 2019 novel coronavirus disease (COVID-19), only 2% of higher education institutions reported that the normal teaching and learning activities were not affected (Malandrino and Sager, 2021). So, to overcome the interruptions caused by the profound pandemic event, online education and homeschooling has been world-widely utilized to a greater extent (Dewi and Wajdi, 2021; Shishakly, 2024).

A few literature review analyses have been conducted in DE research. For example, in 2011, Simonson et al. (2011) summarized the previous studies on the

obstacle to DE delivery and concluded the strategies to improve effectiveness of DE. In 2019, Nair et al. (2019) investigated the research progress of distance education, and therefore suggested some strategies to improve the distance education system. In 2020, He et al. (2021) conducted a meta-analysis to compare the effectiveness and acceptance of synchronous DE in medical students with those of traditional education. In another review, 989 papers published between 2009 and 2016 were selected for examination to identify main concepts and focus in the developmental trends of DE research (Çakiroğlu et al., 2019). In 2016, based on the relevant articles in the Distance Education journal published between 1980 and 2014, a review study summarized the trends of DE research and scholarship (Zawacki-Richter and Naidu, 2016).

Despite the growing interest in DE, especially post-COVID-19, there remains a lack of comprehensive bibliometric analyses that systematically map emerging trends and future directions in DE research. This gap is particularly critical as educational institutions worldwide increasingly rely on DE to enhance accessibility and quality of education. Motivated by this need, our study aims to fill this void by providing a detailed scientometric analysis of DE literature over the past decade, identifying key research trends and potential areas for future investigation. Software programs such as citespace are indispensable in bibliometric analysis (Chen, 2006). Compared with traditional quantitative methodology, such an analysis possesses several merits in terms of efficiency and accuracy. It could identify the research gaps and emerging topics in the specific field and lower readers' cognitive burden comprehensively and objectively (Chen, 2006).

According to the demands in context of investigation in DE, this study aimed to: The aim of our study is to define the frontier of DE research by identifying emerging trends, key terms, and methods that have significantly influenced the development of DE. Consequently, a comprehensive bibliometric analysis on the publications relevant to DE in the period of 2011–2023 could be constructed, which examined the publications, citations, and cooperation structures, thereby summarizing the research trend. To guide this investigation, the following research questions were formulated: What are the key research trends and emerging themes in DE literature from 2011 to 2023? How has the focus of DE research evolved over the past decade, particularly in terms of technological innovations and pedagogical strategies? Which countries, institutions, and authors are leading the field of DE research?

2. Materials and methods

2.1. Data

The primary source of literature was the web of science (WoS) database. Within the primary database, the WoS core collection served as the functional part to select the authoritative journals and publications, as well as the relevant information, according to the inquiries submitted by researchers. The selected articles could be imported into the software conducting the literature analyses.

The data retrieval strategy of the inquiry included following settings: the topic was "distance education"; the results were refined by document types, which could be articles or proceeding papers; the language was English; the time span was 2011–2023; the indexes was web of science core collection. The date of the inquiry was 31

December 2023. Consequently, 5719 records were selected. The raw information was exported in the format of plain text, which could be imported by citespace. Then, the duplicates removal of citespace was run, consequently none record was removed. Therefore, a total of 5719 literature records became the object of the subsequent analytical procedures conducted by citespace 6.1.

2.2. Research tools

In this study, the processed information was saved as "Full Record and Cite References". Then, citespace software was used to perform visualization analysis, in order to determine the research hotspots and the trends of DE (Chen, 2017). Wos bibliometric tool was used for basic analyses. The key features (the number of publications, countries, research area, authors and journals) of DE-related articles were identified via the WoS-based analysis.

The citesapce software was used to construct networks of key items (articles, authors, keywords, and references) connected by citation, co-citation, and co-occurrence links. This algorithm can easily find mutant words in the literature, which is more conducive for users to understand research hotspots in this field. In addition, citespace provides three visualization methods, and the default setting is cluster view (Cluster), which focuses on the structural characteristics of clusters, highlighting key nodes and important connections. The timeline focuses on delineating the relationship between clusters and the historical span of documents in a cluster. The time zone view focuses on the temporal dimension of knowledge evolution, which can clearly show the update and interaction of the literature. Citespace provides automatic clustering based on the spectral clustering algorithm. Parameters were set for citespace analysis. The settings included: link retaining factor (LRF = 2), time span (2011–2023), years per slice (1), links (strength: cosine; scope: within slices), and selection criteria (Top 50).

The analysis involved evaluating the modularity Q values and silhouette (S) values to ensure the quality and reliability of the cluster analysis. Modularity Q Value: The modularity Q value is a measure used to evaluate the strength of the division of a network into clusters (modules). It ranges from 0 to 1, where values between 0.4 and 0.8 are considered reasonable. A higher modularity Q value indicates a clearer structure and better-defined clusters within the network. This value helps to determine how well the network is partitioned into modules, with values above 0.4 indicating a good clustering outcome. Silhouette (S) Value: The silhouette value measures the cohesion and separation of clusters. It ranges from −1 to 1, where a value closer to 1 indicates that the objects are well matched to their own cluster and poorly matched to neighboring clusters. An S value larger than 0.6 is considered to indicate a successful clustering outcome, meaning that the clusters are both cohesive and well-separated from each other.

2.3. Research process

Firstly, we constructed the basic knowledge cluster of DE based on the reference literature in the field. This cluster is essential for identifying the main clusters in the knowledge graph and highlighting the most influential works. It also facilitates the

study of each cluster's evolution, future trends, and key literature from a timeline perspective. Visualizing researchers and research institutions helps identify major contributors to the development of knowledge in vocational education and training. Secondly, hotspots and frontiers in DE are determined by analyzing the frequency of keywords in relevant literature. Finally, keyword bursts reveal the evolution of DE and indicate the latest research trends. In citespace, a burst signifies a significant change in a variable over a short period, which helps identify research frontiers. The whole study process was shown in **Figure 1**.

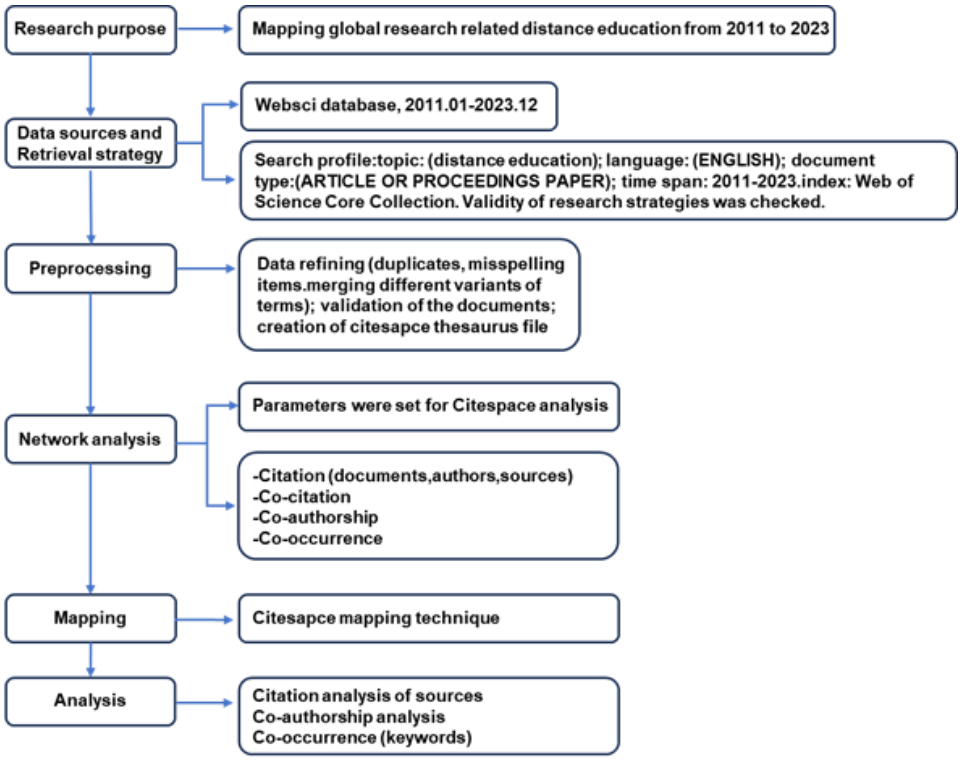

Figure 1. Flowchart of this scientometric analysis based on citespace.

3. Results

3.1. Analysis of annual output

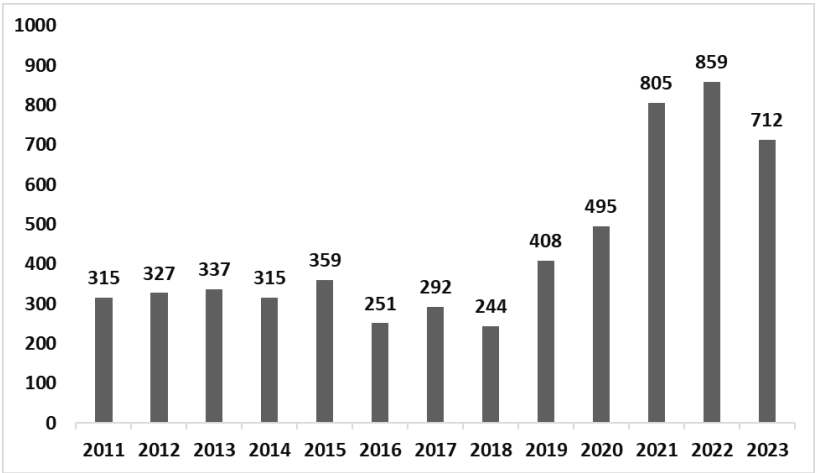

Figure 2. The number of annual researches published.

The upward trend for the annual output was illustrated in **Figure 2**. There were obviously three stages in the trends of publications. From 2011 to 2014, the output trend was relatively flat. In 2015–2019, it was the second stage as a steady upward trend exhibited by the publication quantity from 2014 to 2019. Since 2019, the number of papers had increased sharply from 2019 to 2023, implying that the research interests on DE had been promoted due to the suddenly enhanced requirements. The underlying predominant social event was the pandemic of COVID-19, which actually facilitated the application of DE world-widely.

3.2. Analysis of the key features

The basic data on publications, countries, research areas, authors, and journals were extracted from the WoS database (**Table 1**). The USA leads in DE research output, followed by China, Turkey, Spain, and Brazil. Key institutions include the Open University (USA) and University of South Africa (China), both pivotal in advancing distance education. The Open University is renowned for its contributions to online learning methodologies, while the University of South Africa has excelled in integrating technology into education. Research fields linked to these institutions underscore the interdisciplinary nature of DE, with Education, Educational Research, and Computer Science as primary areas, highlighting the blend of pedagogical strategies and technological innovation. The inclusion of Engineering and Nursing further demonstrates DE's applicability across diverse disciplines. Among the leading authors, Manuel Castro (USA) and Roberto Hernandez (China) stand out for their significant contributions to instructional design and educational technology. The involvement of other prominent researchers, such as Salvador Ros (Turkey) and Antonio Roblesgomez (Spain), illustrates the global collaboration driving DE research forward. This data reflects the broad international and interdisciplinary engagement in the field of distance education.

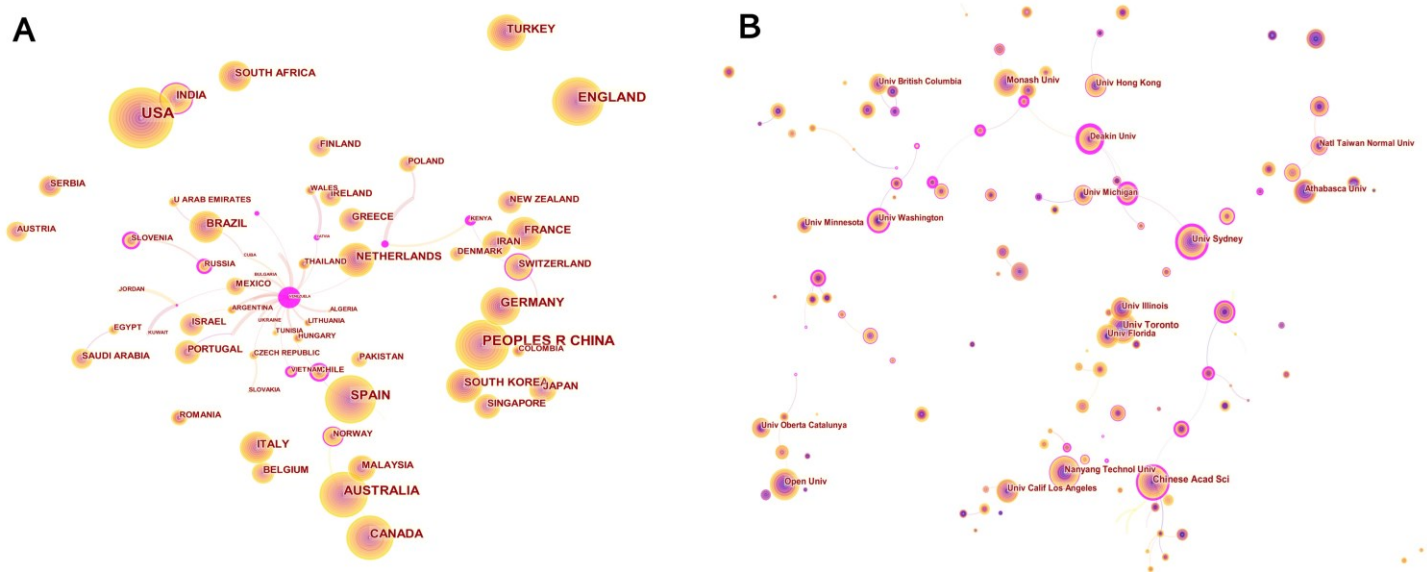

Figure 3. Map of **(A)** countries; **(B)** institutions.

In citespace, the setting of the node type was "Country and Institution", and the

setting of the threshold was top 30, thereby generating the knowledge map to visualize the core strengths (**Figure 3**). In **Figure 3A**, according to co-institute network, the red or purple rings showed that there was more extensive international cooperation on DE research in the USA, China, and Turkey. **Figure 3B** presented the knowledge map of the institution collaboration. Rare cooperation was observed between organizations.

Table 1. Top 10 prolific countries/regions, institutions, research fields, and authors in DE-related research.

Ranking	Country	Institute	Research field	Authors
1	USA	Open University	Education Educational Research	Manuel Castro
2	China	University of South Africa	Computer Science	Roberto Hernanedz
3	Turkey	Anadolu University	Engineering	Salvador Ros
4	Spain	Athabasca University	Nursing	Antonio Roblesgomez
5	Brazil	University of Sao Paulo	Psychology	Aras Bozkurt
6	Australia	University of Florida	Telecommunications	Llanos Tobarra
7	Russia	Universidad Nacional de Educación a Distancia	Science Technology	Elio Sancristobal
8	Canada	Near East University	Business Economics	Jichun Zhao
9	England	Beijing Academy of Agriculture and Forestry Sciences	Health Care Sciences Services	Agustin C. Caminero
10	South Africa	Monash University	Environmental Sciences Ecology	Jianxin Guo

3.3. Analysis of co-cited journals

The top 5 co-cited journals were ranked in terms of centrality (**Table 2**). The journals with most academic influence (centrality) was International Journal of Instructional Media (0.06), Internet and Higher Education (0.05), IEEE Transactions on Learning Technologies (0.05), Decision Sciences-Journal of Innovative Education (0.05), and Journal of Research on Technology in Education (0.04). This suggested that these five journals achieved more attention in the research fields recognized by the platform. The published articles on DE in the journals mainly focused on computer mediated communications, online learning, teaching, and innovative online learning systems.

Table 2. Top 5 Journals according to centrality.

Ranking	Centrality	Citation frequency	Journal	Citation half-life
1	0.06	113	International Journal of Instructional Media	4.5
2	0.05	360	Internet and Higher Education	5.5
3	0.05	101	IEEE Transactions on Learning Technologies	5.5
4	0.05	75	Decision Sciences-Journal of Innovative Education	5.5
5	0.04	105	Journal of Research on Technology in Education	1.5

3.4. Analysis of co-cited reference

The co-citation analysis of references was aimed to present the research trend. The co-citation map of references was showed in **Figure 4**. **Table 3** showed the top 5 references in terms of the co-citation frequency, which could lay a foundation for future researches. Significantly, four of the top five articles focused on the educational methods of DE.

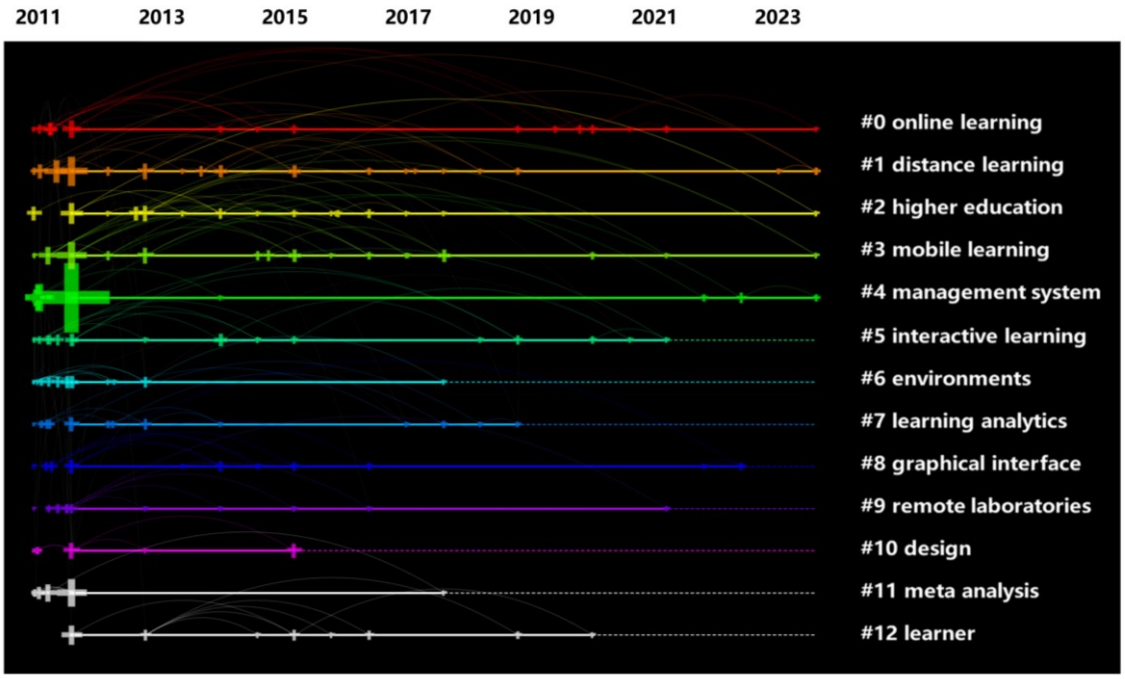

Figure 4. Map of reference co-citation clusters.

Table 3. Top 5 references in terms of number of co-citations.

Ranking	Co-citation	Cited reference
1	47	Three generations of distance education pedagogy (Anderson and Dron, 2011)
2	32	MOOCs: a systematic study of the published literature 2008–2012 (Liyanagunawardena et al., 2013)
3	30	COVID-19 and online teaching in higher education: a case study of Peking university (Bao, 2020)
4	24	Mapping research trends from 35 years of publications in distance education (Zawacki-Richter, 2016)
5	21	Initial trends in enrolment and completion of massive open online courses (Jordan, 2014)

The article published by Anderson and Dron. (2011) had the maximum citation frequency (47). In this article, the authors examined and analysed three generations of distance education pedagogy and focused on the pedagogy that defined the learning experiences encapsulated in the learning design. The article with the second highest citation frequency (32) was written by Liyanagunawardena et al. (2013). This systematic study classified relevant literature into eight research areas of interest and conducted quantitative analyses on these findings from three aspects. The article with the third highest citation frequency (30) was a case study conducted by Bao. et al. (2020), in which they proposed six specific teaching strategies and summarized the online teaching experience of university staff in the context of COVID-19.

Figure 5 shows the timelines of the clusters, and the top 13 clusters based on the cited articles. It illustrates the clusters of the collected articles from 2011 to 2023 through the timeline. As the automatic selection of cluster labels was based on the contemporarily popular terms in DE research, the status of the mainstream research work could be represented. For 13 major clusters, the cluster labels were listed, as well as the cluster size, identity number and silhouette value. The largest cluster of DE (#0) was “online learning, which was active from 2013 to 2018, meaning that in 2013 online learning gradually became the research hotspot for academic mobility. The

second largest cluster (#1) was distance learning, which was active from 2011 to 2016. The third largest cluster was higher education (#2), which was active from 2012 to 2015.

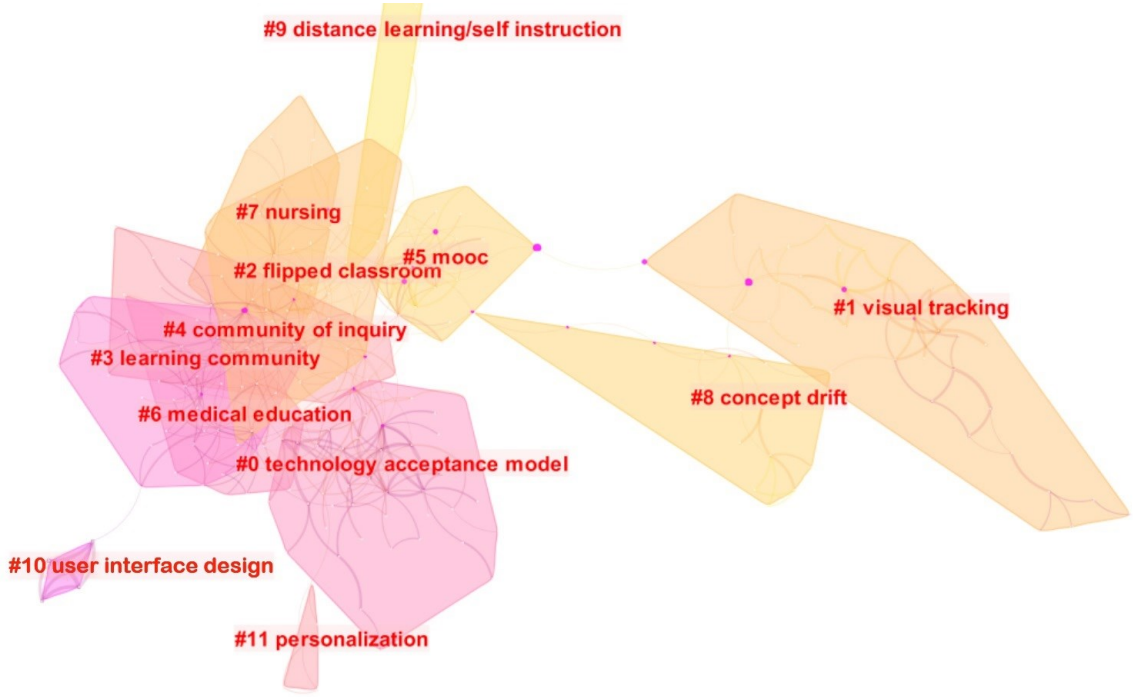

Figure 5. Co-citation clusters about distance education theme.

3.5. Cluster view of keyword analysis

To analyze co-occurrence, the frequencies of some assigned keywords were required to be examined in the same group of selected articles, thereby evaluating the correlations between them with co-occurrence values. There were 14 keyword clusters demonstrated in **Figure 5**. The values for Q and S were referenced to evaluate how well the domain is classified into clusters. Modularity Q values ranging from 0.4 to 0.8 are reasonable, and an S value larger than 0.6 means the clusters are successful (Rousseeuw, 1987). It can be deduced from this figure that Modularity Q = 0.7 and mean Silhouette = 0.9 mean the clustering outcome is suitable for further analysis. The largest cluster (#0) was labelled "technology acceptance model". The second largest cluster (#1) was labelled "visual tracking". Other clusters included flipped classroom, learning community, community of inquiry, medical education, nursing, concept drift, distance learning/self instruction, user interface design, and personalization.

3.6. Keywords citation bursts

By establishing the timeframe for the sudden occurrences, the analysis of the burst time for the keywords could further investigate the tendencies in DE research. According to the citation frequency, the top 20 keywords were listed in **Table 4**. These keywords covered different aspects of DE, which were summarized into three classes: technologies (remote laboratory, virtual learning environment, and social media), strategies (distance education, adult learning, learning strategy, Design, User interface, and MOOC), and effectiveness (feedback, technology acceptance, experience, self-

efficacy, and engagement).

Table 4. Top 20 keywords with the strongest citation bursts in distance education area.

Keyword	Strength	Begin	End
Distance education	16.2	2011	2014
Adult learning	15.2	2011	2014
Remote laboratory	15.1	2011	2014
Learning strategy	14.7	2012	2014
Design	13.9	2012	2016
Virtual learning environment	13.8	2013	2016
Feedback	12.6	2013	2016
Communication	12.6	2013	2016
Social media	11.7	2014	2018
MOOC	11.5	2016	2018
Web	10.1	2017	2020
Augmented reality	8.6	2017	2020
Communication	7.1	2017	2020
Digital learning	6.8	2019	2021
User interface	6.5	2019	2021
Self efficacy	6.2	2019	2021
Engagement	5.3	2020	2023
Learner	4.6	2020	2023
Open education resources	4.5	2020	2023
Technology acceptance	4.0	2020	2023

4. Discussion

In the bibliometric study, based on the literature acquired from the WOS database, the knowledge maps were generated by citespace, in order to visualize the tends and status in DE research, regarding the variety of publications, nation, research direction, and co-citation analysis. As shown in the tables and figures above, involving the most influential authors, journals, countries, institutions, and keywords have been identified.

According to the results from WOS-based analyses, scholars were more concerned about the field of Education and Educational Research, as well as Computer Science. The publications of DE showed an upward trend approximately in 2018. The most productive institution (Univ Calif Los Angeles) was from the USA, which complied with ranking of the influences by the nations in DE research (Kentnor, 2015). There were 213 connections among countries/regions, suggesting corresponding levels of exchange and cooperation between those entities in DE research. While the USA holds the highest number of publications, the distribution of these publications is scattered across many institutions. This dispersion can be attributed to the interdisciplinary nature of distance education research, which spans various fields such as education, computer science, engineering, and health sciences (D'Este and Robinson-García, 2023). This interdisciplinary approach leads to contributions from a

diverse array of departments and faculties within universities. In compliance with the trends of globalization, it was recommendable to encourage cross-regional academic exchanges and cooperation, thereby facilitating the optimization of the current DE system. In addition, according to co-citation analysis, the centrality of top 10 journals exceeded the threshold value, proving that the average quality and significance of the DE-related article published by them were outstanding (Costenbader and Valente, 2003).

The co-citation analysis revealed 14 prominent clusters that were concentrated and overlapping, indicating shared relevance among hot topics in DE research. This clustering highlights the evolution of DE into an increasingly digital and technology-driven field, with significant clusters such as online learning, distance learning, and blended learning underscoring the shift towards online education facilitated by advancements in digital technology (Kim et al., 2023). The largest cluster, online learning (#0), active from 2013 to 2018, reflects the growing interest in digital learning platforms during this period. This trend aligns with the global increase in internet accessibility and the proliferation of online educational resources (Castro, 2019). The distance learning cluster (#1), active from 2011 to 2016, captures foundational research in remote education methods, while the mobile learning (#2) and interactive learning cluster (#5), active from 2012 to 2015, highlights the integration of online and face-to-face instruction. The analysis further indicates substantial interest in online learning communities and MOOCs, which have democratized access to education, enabling diverse learners to participate in high-quality educational experiences (Barger, 2020). The distance education industry thinks more about the care and needs of the students, design and technology acceptance has become a popular topic of research. As indicated from the academic view, the research direction of user interface design is closer to the society hot trends and interdisciplinary research. Caring for learner's physical, physiological and psychological aspects, future research tends to be more students centered design.

In consistent with label clustering results, the burst detection of keywords clarified that "engagement", "learner", and "device" were the hot topics in DE. Obviously, the engagement in education was an important factor to determine the learning results (Yilmaz, 2017). In 2020, by investigating the learning experience of 574 undergraduate students, Justine Ferrer et al. noted that students' motivation and engagement was essential to online learning, since there were some students becoming unmotivated in DE environment (Ferrer et al., 2020). These studies confirmed that internet-based courses or e-learning had emerged as an alternative or substantial supplement to traditional teaching, however, educators should design DE programs with the deliberate intent to ensure the motivation and engagement of students.

Keyword burst detection focused on the sudden changes of hot spots in the research field, which could be remarkably effectual in predicting the development trend of the topic (Chang et al., 2015). The burst word and time zone view shown that, due to the rapid increase in DE application and the tremendous potential, numerous research projects had recognized the demands to ensure and improve the quality and effectiveness. However, the quality assurance of DE relies on the basic skills of the teaching staff, particularly the ability to apply information technology (de Oliveira et al., 2018). Also, educators should design DE environments with the consideration to

optimize the communication between the teachers and the learners. The focuses of future studies on DE would be how to effectively explore the value behind the data, and how to promote teaching effectiveness (Hollenbeck and Shi, 2021). Moreover, the independent learning and self-discipline abilities of the students could be greatly challenged in a DE course. Without the conditions of face-to-face communications, the ability of teachers to keep the students concentrating on studying might be compromised. As proposed by Shearer et al. (2020), "What is it that students and faculty want today in their online learning experiences?". In their study, the main concern was not just about technology, but on the quality of education (Shearer et al., 2020).

The time zone view of keywords demonstrated that effective educational guidance and support at home was another major research topic. The pandemic could interrupt the child education for the low-income families to a greater extent, and therefore increased the demands of low-cost and widely accessible devices, such as inexpensive smart phones meeting the basic requirements of the mainstream DE applications, to ensure the participance of those students in the necessary DE courses (Muralidharan and Singh, 2021). Two systematic studies of the top five Top 5 concerned the MOOC as a DE strategy (Jordan, 2014; Liyanagunawardena et al., 2013). The outstanding advantage of MOOC was the efficiency and convenience to allow the participance of learners with various educational and cultural background, thereby facilitating the knowledge distribution in the context of globalization (Guerrero et al., 2021), especially during pandemic. In 2021, A RE-AIM (reach, effectiveness, adoption, implementation, and maintenance) framework was utilized to evaluate the effectiveness of MOOC in teaching medical students about COVID-19. This study suggested that MOOCs had the potential to become increasingly critical in the education system, for example, it could enable the medical students and even clinicians to timely update their professional knowledge and skills in future public health emergencies (Yilmaz et al., 2021).

Policy-makers should foster international partnerships to bridge gaps in research and practice. For instance, collaborative initiatives between institutions in developed and developing countries can enhance resource sharing and knowledge transfer. This approach can help address educational inequalities and improve the quality of distance education globally (Muralidharan and Singh, 2021). Governments should allocate more funding to distance education initiatives, particularly in regions with lower research output. This can help build robust educational infrastructures, support professional development for educators, and ensure that students have access to necessary resources. Increased funding can also support the development of innovative technologies that enhance the learning experience. Educational institutions should adopt interactive and adaptive learning technologies, such as gamification, virtual reality environments, and personalized learning pathways, to maintain student motivation, and engagement. The rapid advancement of technology has significantly impacted distance education (Reginald, 2023).

5. Conclusions

Our study explored the current status and trends in DE studies using citespace,

and provided a perspective to the emerging trends of DE.

1) In the acquisition of data, the validation and optimization of the search strategy proved to be essential for obtaining a reliable basic data set. The preprocessing phase was crucial to improve the quality of the initial raw data set for the science mapping analysis. Citespace software was applied for science mapping visualizations.
2) DE research generally shows a rapid development trend from 2018. The USA, China, and Turkey, together with the institutions from these countries, are highly active in the field of DE. However, very few inter-institutional cooperation networks are found. This study reveals that researchers still tend to work in groups in their respective institutions to enrich the research of DE. Education and Educational Research was the most prolific field, followed by Computer Science, and Engineering. Large numbers of publications on DE are sourced from the journals including International Journal of Instructional Media, Internet and Higher Education, IEEE Transactions on Learning Technologies.
3) Based on the literature review, the emerging trends in the recent DE research were recognized. According to the burst detection of hotspots in DE research, self-efficacy had emerged to become one of the predominant focus points, consequent to the wider application of DE after the onset of COVID-19 pandemic. The main research hotspots were “user interface design”, “engagement”, and “technology acceptance”. Meanwhile, the findings showed that DE was most often studied through quantitative surveys. It is suggested that more studies with different design of methodologies should be conducted.
4) The authors are also aware of some potential limitations. For technical reasons, citespace software could only analyze the data acquired from a single source at a time, and therefore the documents in other literature databases could not be included. As the WOS database was not expected to contain all the DE-related publications, the selection bias could not be excluded. Another potential limitation of our study is the exclusive use of “distance education” as the primary keyword for literature retrieval, which may have led to the omission of some studies that focus specifically on “online education”. While distance education includes a variety of non-face-to-face educational methods, online education specifically refers to those conducted entirely over the internet. Finally, the analytical procedures conducted by citespace mainly based on frequency and centrality; however, the validity of centrality evaluation relied on the number of nodes. Due to the limitations inherent in a study of this type, the subsequent in-depth investigation was required to verify the findings.

The current study provides a deeper understanding of how DE research is progressing. Its goal is to raise the visibility of research on this topic by presenting retrospective and comprehensive review of publications. Deeper and more rigorous researches are needed in the future, such as integrating AI-driven learning analytics, mobile learning applications, user interface design, and virtual laboratories to enhance educational outcomes.

Author contributions: Conceptualization, JZ and PH; methodology, JZ; software, JZ; validation, JZ and PH; formal analysis, PH; investigation, JZ; resources, JZ; data

curation, JZ; writing—original draft preparation, JZ; writing—review and editing, OY; visualization, PH; supervision, OY; project administration, OY; funding acquisition, JZ. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest: The authors declare no conflict of interest.

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