

Mapping the Landscape of e-Learning Research: A Bibliometric Analysis

Norliza Muhamad Yusof¹, Muhamad Luqman Sapini^{1,2*}, Muhammad
Zulqarnain Mohd Nasir³, Mohd Nur Fitri Mohd Salim⁴

¹College of Computing, Informatics and Mathematics, Universiti Teknologi MARA
Cawangan Negeri Sembilan, Kampus Seremban, 70300 Seremban,
Negeri Sembilan, Malaysia
norliza3111@uitm.edu.my

²School of Mathematical Sciences, Universiti Kebangsaan Malaysia,
43600 UKM Bangi, Selangor, Malaysia
luqman0211@uitm.edu.my

³Faculty of Sports Science & Recreation, Universiti Teknologi MARA
Cawangan Negeri Sembilan, Kampus Seremban, 70300 Seremban,
Negeri Sembilan, Malaysia
zulqarnain9837@uitm.edu.my

⁴Akademi Pengajian Bahasa, Universiti Teknologi MARA
Cawangan Negeri Sembilan, Kampus Seremban, 70300 Seremban,
Negeri Sembilan, Malaysia
fitrisalim@uitm.edu.my

*Corresponding Author

Received: 15 November 2024

Accepted: 25 December 2024

Date Published Online: 1 January 2024

Published: 1 January 2024

Abstract: This research conducts a comprehensive bibliometric analysis of academic publications on e-learning, aiming to gain perspectives on the state of the field, and the emergence of patterns within this field of study. A systematic search was conducted in the Scopus database, yielding 1983 documents related to e-learning. The network analysis focused on keyword distribution, country representation, and co-authorship using VOSViewer software and weighted degree centrality. The keyword analysis revealed “e-learning” as the dominant and central theme, highlighting its significance in the research domain. The emergence of “Covid-19” as a widely used keyword for searches implied that the pandemic affected e-learning activities. Moreover, the representation of institutions from diverse countries showcased the global interest in e-learning research, fostering

potential cross-cultural collaborations. Additionally, the increasing trend in e-learning research publications over the years indicated the growing importance of digital education. The interdisciplinary nature of e-learning research, spanning Computer Science, Social Sciences, Engineering, and Medicine, underscored the field's diverse perspectives. Furthermore, the Social Network Analysis unveiled collaborative networks of co-cited authors, regions, and keywords, illuminating the interconnectedness within the e-learning research community. The findings contribute to a better understanding of the e-learning research landscape, facilitating informed decision-making for researchers, educators, policymakers, and institutions. Likewise, the analysis provides valuable insights for future research directions, enabling advancements in e-learning practices and fostering innovation in the digital age.

Keywords: *Bibliometric analysis, centrality, e-learning, network analysis, VOSViewer.*

INTRODUCTION

e-Learning refers to the utilization of electronic media and information and communication technologies (ICT) within the field of education. It comprises various components, including online courses, webinars, collaborative learning environments, and digital game-based learning (Silverstru et al., 2018). The occurrence of e-learning has experienced a significant rise in recent years because of improvements in technology (Kimura et al., 2023), evolving societal norms, and the occurrence of crises such as the COVID-19 epidemic (Brika et al., 2021), which required a transition from traditional classroom teaching to online learning platforms (Law et al., 2022). Hence, a growing body of research and literature on e-learning has emerged, creating an opportune environment for conducting bibliometric analysis (Castillo-Velazquez & Silva-Lopez, 2022). Bibliometrics is a statistical analysis of written publications that offer quantitative insights into the patterns of academic literature (Jaradat et al., 2022). These insights, garnered from citation analysis, content categorization, co-citation analysis, and other such techniques, provide valuable information about the prominence of authors, articles, and topics within a field of study (Chen, 2017). In essence, bibliometric analysis serves as a microscope through which we

can view the dissemination and impact of knowledge within a particular academic landscape (Chiroma et al., 2020). E-learning is a rapidly evolving field, with an accelerating pace of development fuelled by technological advancement and societal change (Sweileh, 2021). As a result, the literature on e-learning is vast, diverse, and continually growing (López-Robles et al., 2020). The diversity and complexity of e-learning research make it challenging to draw connections between different works, discern patterns of influence and citation, or gain an overview of the field. Despite these challenges, there has been a lack of comprehensive bibliometric analysis within the e-learning field, particularly in network analysis. Such analysis could provide valuable insights into the structure and trends of e-learning research, offering a clearer picture of the knowledge landscape within this field. Therefore, there is a pressing need for detailed, comprehensive bibliometric studies focusing on e-learning to help scholars, educators, and policymakers better understand and navigate this complex field. This study aims to conduct a comprehensive bibliometric analysis of the literature in the e-learning field, seeking to understand the breadth and depth of scholarly work within this evolving field.

2. DATA ACQUISITION AND QUERY CRITERIA

In this research, we employed a bibliometric analysis approach to examine the research publications published in the e-learning domain. A search was conducted on the specified topic with the Scopus database on July 12, 2023. For this research, we concentrated on e-learning publications published over the past five years and selected them based on their titles, abstracts, and keywords. These were identified using the particular query:

TITLE-ABS-KEY (elearning OR “electronic* learning*”) AND (LIMIT-TO (PUBYEAR, 2023) OR LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019)). Through this search, we came up with a total of 1988 documents. However, there were some duplicates within the data obtained. By removing these identical records, there were 1983 academic documents available for further detail analysis. We extracted relevant results and findings from the documents received, such as the publication year, author, subject area, keywords, affiliation, country/region, and language.

3. BIBLIOMETRIC ANALYSIS TOOLS AND SOCIAL NETWORK ANALYSIS

In the framework of this investigation, the data processing and analysis methods were carried out by utilizing software such as Microsoft Excel 365 and Harzing's Publish or Perish. The data collected from the Scopus database are compiled and examined with Microsoft Excel 365, incorporating the associated figures and tables. The Publish or Perish program developed by Harzing (2007) was employed in retrieving and analyzing citations found in Scopus and Google Scholar. Social Network Analysis (SNA) was used to analyse co-occurrence from a critical perspective. SNA is a comprehensive scientific and theoretical framework employed to examine and analyse the complex networks and interconnections among individuals, organizations, or other entities (Butts, 2008). SNA comprises two fundamental components: Nodes, which represent distinct entities within the network, and Edges, which represent the links or interactions between these entities (Sreejith et al., 2016). The VOSViewer software was utilized to evaluate the co-cited authors, countries, and keywords to visually represent the networks (Van Eck & Waltman, 2010). Centrality is a concept used in SNA to measure the importance of nodes within a network (Sapini et al., 2022). It quantifies the degree to which a node is positioned at the center or core of the network, indicating its influence, control, or access to the information within the social structure (Gopalakrishnan et al., 2020). In this research, Weighted Degree Centrality (WDC) was employed as a method for analyzing the network model. WDC is one of the tools within the framework of Centrality (Candeloro et al., 2016). To calculate the WDC of a node, it is necessary to aggregate the weights of all the edges linked to this node. Nodes with a higher WDC exhibit more robust and significant relationships with other nodes in the network, indicating their heightened impact or centrality within the weighted network.

4. RESULT AND ANALYSIS

This section presents the results and analysis obtained from the bibliometric analysis done. The results and analysis are presented in the form of Tables and Figures as shown and explained according to the following sub-sections.

4.1 YEAR OF PUBLICATIONS

Figure 1 shows an increase in the number of publications related to e-learning from 2019 to 2021, indicating rising interest and research activity on the topic. This pattern coincides with the quickening pace of technological advancement and the growing prevalence of digital resources in educational settings. According to the data, the number of publications in recent years has been relatively high, with 2021 having the most significant count. This shows that e-learning will continue to be a dynamic and busy study topic, with new methods being investigated and continual technological developments. The increased number of publications in recent years may also indicate the growing significance of e-learning, particularly as a response to the shift towards online and blended learning that has occurred worldwide during the COVID-19 epidemic. As of July 2023, the Scopus database had added 185 new articles to its collection in 2023. Consequently, it is anticipated that more additions will follow.

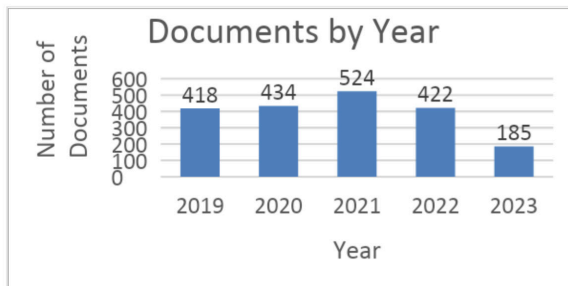


Fig. 1 Yearly publication on e-learning

4.2 LANGUAGE

According to Table 1, a large proportion (more than 90%) of the obtained documents were written in English (99.34%). English dominates the e-learning research landscape with 1928 documents. As the global lingua franca of academic communication, English is the primary language for scholarly publishing and knowledge dissemination. Most of the e-learning research is conducted and published in English, allowing it to reach a broad international audience. Although the use of languages other than English has a percentage of less than one percent, encouraging more publications in these

languages would promote diversity, inclusivity, and cross-cultural exchange of e-learning research. Local researchers can disseminate findings within their linguistic communities while fostering international collaboration.

Table 1. Documents languages

Language	No. of Document	Language	No. of Document	Language	No. of Document
English	1928	Portuguese	5	Arabic	2
Spanish	41	Persian	4	Indonesian	1
Russian	27	Italian	3	French	1
German	20	Chinese	2	Afrikaans	1

4.3 DOCUMENT AND SOURCE TYPE

Articles are the most common document type in e-learning research, with 1109 publications, as shown in Table 2. Articles typically represent original research, empirical studies, theoretical explorations, or case studies. They are the backbone of scholarly communication, presenting new findings and contributing to advancing knowledge in the field. Table 3 displays five types of sources related to the field of e-learning that have been published. Journals are the most common category, with conference proceedings ranked second in distribution. Journals are frequently seen as more reputable than other sources in academic circles. A journal’s impact factor is a measure of its significance in the scientific community, and publishing in a high-impact journal can boost a researcher’s profile and career. As a result, researchers may be more likely to submit their findings to peer-reviewed journals.

Table 2. Document Type

Document Type	Number of Documents	Document Type	Number of Documents
Article	1109	Note	7
Conference paper	691	Letter	3
Book chapter	96	Editorial	3
Review	66	Short survey	2
Conference review	38	Erratum	1
Book	11	Data paper	1

Table 3. Source Type

Source Type	Journal	Conference proceeding	Book series	Book	Trade journal
Number of Documents	1192	601	159	73	3

4.4 SUBJECT AREA

This research presents documents based on their subject areas, as shown in Figure 2. Computer science has the highest number of publications among the subject areas in the dataset. The dominance of computer science in e-learning publications aligns with technology's significant role in shaping and facilitating e-learning environments. Computer science disciplines such as artificial intelligence, machine learning, human-computer interaction, and data science have increasingly been integrated into e-learning practices, leading to innovative approaches and advancements. Social sciences has the second highest number of publications among the subject areas in the dataset. The dominance of social sciences in e-learning publications signifies the importance of understanding the social and human aspects of e-learning, including learner engagement, motivation, collaboration, cultural influences, and the impact of e-learning on educational outcomes. Other than that, there are a variety of subjects where e-learning can be applied, such as Mathematics, Pure Sciences (Physics, Medicine, Energy), Business and Management, and Engineering.

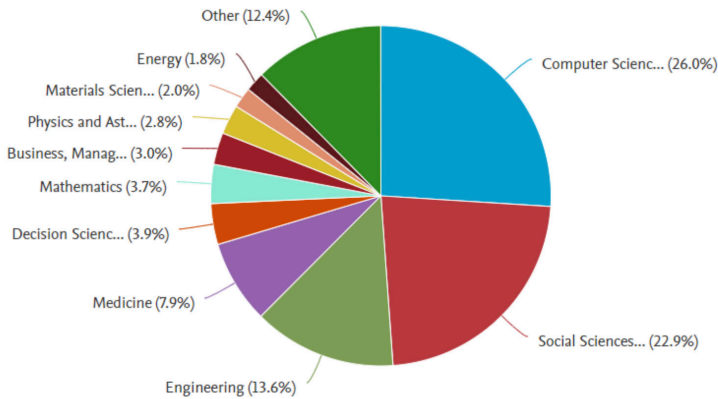


Fig. 2 Subject Area

4.5 KEYWORD ANALYSIS

Table 4 shows the 20 most-used keywords (in frequency) from e-learning publications. The Weighted Degree Centrality (WDC) represents a keyword’s total number of co-occurrences with other keywords, indicating the keyword’s centrality in the e-learning research network. The most prevalent keyword was “e-learning,” which occurred 1560 times and had the highest WDC value of 2425. This demonstrated its central position and extensive connectivity within the research network. Other frequently occurring and influential keywords included “Human” (516 occurrences, WDC: 1621) and “Students” (395 occurrences, WDC: 1214). This indicates that recent studies are focused on understanding the human aspects of e-learning and exploring the students learning experiences. There are several keywords with high frequency and WDC values, including “e-learning,” “Human,” “Students,” “Learning systems,” and “Electronic learning.” These keywords have a high frequency of occurrence and a high WDC value, indicating a positive correlation. In other words, the most common keywords are also highly central and interconnected throughout the e-learning research network. This positive correlation indicates that the most frequently used keywords in e-learning research are prevalent and significant in connecting the field’s various themes and topics. Researchers tend to concentrate on these central keywords, and their work often collides with other e-learning-related research fields.

Table 4. Top 20 keywords in e-learning

Keyword	Occurrence	WDC	Keyword	Occurrence	WDC
e-learning	1560	2425	Learning	153	819
Human	516	1621	Female	121	943
Students	395	1214	Engineering education	120	359
Learning systems	302	836	Male	115	912
Electronic learning	246	686	Medical Education	112	643
Education	232	1089	Online learning	107	279
Teaching	208	1042	Adult	107	835
Covid-19	186	603	Education computing	102	400
Article	174	1167	Pandemic	73	413
Computer-aided instruction	166	484	Curriculum	65	407

VOSViewer, a bibliometric network creation and visualization software program, was used to map and visualize the author’s keywords. The network representation of the author’s keywords is illustrated in Figure 3. In this visualization, nodes are utilized to represent keywords, while edges

Mapping the Landscape of e-Learning Research: A Bibliometric Analysis

are employed to indicate relationships with other keywords, specifically co-occurrence. Additionally, color is employed to signify the cluster to which each keyword belongs. Clusters consisted of keywords of the same color. The fundamental themes in e-learning research were represented by the green cluster of keywords, which included “e-learning,” “teaching,” “electronic learning,” and others. These keywords have many occurrences and WDC values, showing their importance in the research network. The blue cluster included the keywords “pandemic” and “Covid-19,” indicating the importance of the Covid-19 pandemic in e-learning research. The frequency with which “Covid-19” appeared (186 times) emphasized its significance as a driving factor in the e-learning scene. The red cluster included scientific terms like “controlled study” as well as demographic terms like “adult,” “female,” and “male.” These keywords emphasized the various approaches and educational elements incorporated into e-learning research. Overall, the keyword analysis found that core themes in e-learning research include e-learning, teaching, and electronic learning. The Covid-19 epidemic significantly impacted the field, with researchers looking at its implications to e-learning. Additionally, the wide diversity of approaches and demographic factors reflected the broad characteristic of e-learning research.

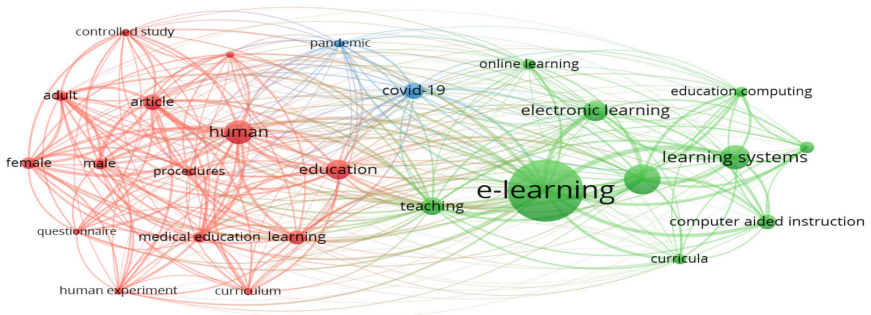


Fig. 3 Keyword co-occurrence network visualization

4.6 COUNTRY DISTRIBUTION

The geographical distribution of scholarly contributions and collaborative patterns among countries play a vital role in shaping the global landscape of e-learning research. The retrieved documents feature contributions from authors originating in 74 different nations. Table 5 lists the top 20 countries

by the number of publications associated with e-learning. The United States emerges as a dominant force in e-learning research, contributing a substantial number of documents (204) and exhibiting a high WDC value of 94, indicating its significant collaborative engagement with other countries. Similarly, countries like Indonesia, India, Spain, the United Kingdom, Saudi Arabia, and Malaysia exhibit notable research outputs, showcasing varying degrees of collaboration with other nations. European countries, including Germany, Romania, Spain, also strongly dominate this research area. Notably, the United Kingdom stands out with a high WDC value of 79, reflecting its robust international collaborations. Several other countries, such as South Africa, China, Iraq, Italy, and Jordan, significantly contribute to e-learning research with moderate to lower levels of collaboration. Meanwhile, countries like Norway, Sweden, and Netherlands demonstrate active engagement with moderate collaboration, enriching the global e-learning research network.

Table 5. Top 20 e-learning research countries

Country/Territory	Documents	WDC	Country/Territory	Documents	WDC
United States	204	94	Canada	68	68
Indonesia	142	15	Romania	64	28
India	126	29	South Africa	64	24
Spain	115	37	China	46	23
United Kingdom	109	79	Iraq	44	13
Germany	92	33	Italy	40	53
Saudi Arabia	87	44	Jordan	40	24
Malaysia	84	48	Iran	36	14
Russian Federation	81	28	Czech Republic	31	17
Australia	79	34	Netherlands	30	36

Figure 4 presents the authors’ network visualization map, constructed based on their associations with different countries. The authors’ network visualization using VOSViewer highlights three significant clusters of countries with strong collaborative relationships in the e-learning research domain. The blue cluster represents Middle Eastern and Asian countries with substantial collaboration, the green cluster comprises European countries with active cross-border collaborations, and the red cluster includes countries from different continents engaged in extensive international partnerships. These collaborative clusters are consistent with Table 5, which showed specific countries with high numbers of e-learning research documents and significant WDC values, indicating their central roles in the collaborative network. The visualization reinforces the global

Mapping the Landscape of e-Learning Research: A Bibliometric Analysis

interest and engagement in e-learning research, as countries from various regions actively collaborate to advance the field. These collaborative efforts contribute to the diverse perspectives, methodologies, and innovations in e-learning research, enriching the global knowledge base in this domain.

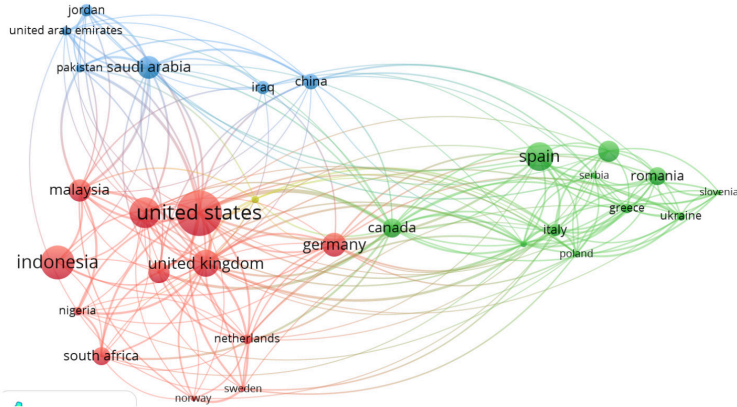


Fig. 4 e-Learning country co-authorship

4.7 AUTHORSHIP ANALYSIS

The analysis of authorship in e-learning research highlights the contributions and impact of individual authors. Table 6 is a compilation of the authors who have demonstrated the highest activity level, as evidenced by their minimum of five publications. Some authors, such as Pikhart, M., García-Peñalvo, F.J., Stuby, L., Suppan, L., and Suppan, M., stand out with their significant research output and high citation counts. Their solid collaborative engagement is also reflected by their relatively high WDC values. These authors have likely played pivotal roles in connecting and advancing research in the e-learning domain.

Table 6. Top 10 leading authors in e-learning research

Name of Author	No. of document	No. of citation	WDC	Name of Author	No. of document	No. of citation	WDC
Pikhart, M.	13	87	7	Klimova, B.	5	17	4
García-Peñalvo, F.J.	11	575	5	Stuby, L.	5	79	14
Ivanova, M.	6	10	0	Suppan, L.	5	79	14
Alonso De Castro, M.G.	5	49	5	Suppan, M.	5	79	14
Ayub, E.	5	10	2	Tick, A.	5	80	0

Next, the co-authorship analysis is carried out with the help of VOSViewer to investigate the authors' collaborative work. This study analyses the collaboration of the authors by conducting the co-authorship analysis using VOSViewer. As shown in Figure 5, the authors' network visualisation map includes 20 authors and 18 clusters, indicating a highly fragmented and specialised research landscape within the e-learning domain. Numerous small clusters, each comprising at most three authors, suggest that the e-learning research community comprises several distinct and tightly-knit research groups with specific research interests. The small size of each cluster indicates that authors within the same cluster are closely connected and likely to collaborate extensively. While the specialized clusters indicate strong collaboration within each group, it may pose challenges for broader collaboration and cross-pollination of ideas across the entire e-learning research landscape. The small size of the clusters might limit the exchange of knowledge and ideas between authors working in different areas of e-learning. Thus, to promote knowledge exchange, interdisciplinary bridges, and a more cohesive research community, efforts can be made to foster collaboration and communication across diverse clusters and encourage the exploration of emerging trends and interdisciplinary intersections.

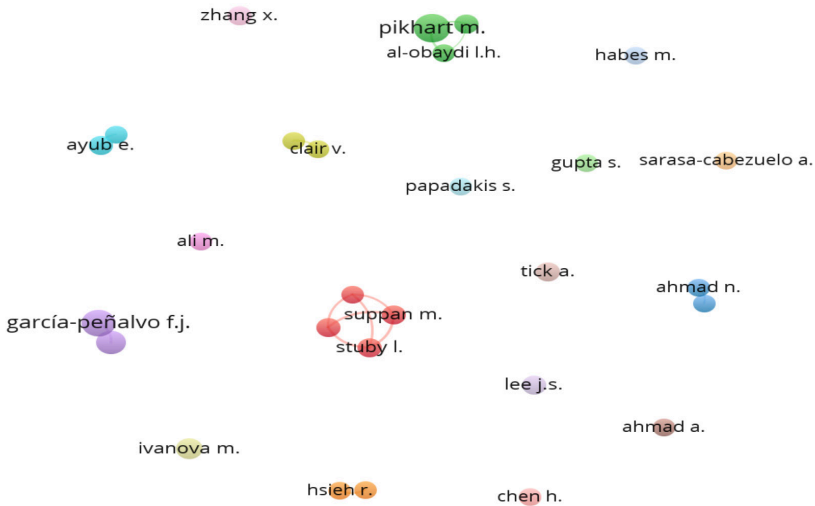


Fig. 5 e-Learning co-authorship network

4.8 CITATION ANALYSIS

Harzing’s Publish or Perish software was employed to evaluate citation metrics for the dataset obtained from the Scopus and Google Scholar (GS) databases. The data shown in Table 7 pertains to the number of citations received by each paper and the average number of citations every year. This analysis helps to identify the most influential and widely cited papers in the e-learning domain, giving insights into the impact and relevance of these research works. The high occurrence of the keyword “Covid-19” in the most cited papers implies that researchers have been keenly investigating the implications of the pandemic on educational practices and the rapid adoption of e-learning during this period. The Covid-19 crisis forced educational institutions worldwide to shift from traditional classroom-based teaching to remote and online learning, leading to an increased interest in e-learning research as an alternative and effective mode of education. The presence of two non-Scopus indexed papers among the top ten references indicates that e-learning research is published in diverse publication channels beyond those covered by Scopus. These emphasize the importance of considering multiple databases and sources to ensure comprehensive coverage of relevant literature in e-learning.

Table 7. Top 10 referenced e-learning papers.

No.	Documents	Scopus Cited by	Scopus Cites per year	GS Cited by	GS Cites per year
1	(Almaiah et al., 2020)	483	161	1203	401
2	(Al-Fraihat et al., 2020)	439	146.33	983	327.67
3	(Abbasi et al., 2020)	300	100	803	267.67
4	(Favale et al., 2020)	312	104	742	247.33
5	(Hasan & Bao, 2020)	285	95	706	235.33
6	(Mailizar et al., 2020)	296	98.67	659	219.67
7	(Aboagye et al., 2020)	NA	NA	639	319.5
8	(Alsoufi et al., 2020)	278	92.67	627	209
9	(R.Radha Dr.V.Sathish Kumar, Dr.AR.Saravanakumar, 2020)	NA	NA	627	209
10	(Alqhtani & Rajkhan, 2020)	235	78.33	626	208.67

4.9 MOST ACTIVE SOURCE TITLE

This research additionally provides the title of the most often cited source, referenced in 20 or more e-learning papers (refer to Table 8). The Institute of Electrical and Electronics Engineers (IEEE) is recognized as one of the leading publishers in the e-learning field, making significant contributions to scholarly publications in this domain.

Table 8. Most active source title

Source	No. of document
IEEE Access	48
Elearning And Software For Education Conference	47
ACM International Conference Proceeding Series	43
International Journal Of Emerging Technologies In Learning	43
Journal Of Physics Conference Series	41
Ceur Workshop Proceedings	30
Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	26
Advances In Intelligent Systems And Computing	25
Lecture Notes In Networks And Systems	23
AIP Conference Proceedings	21
Sustainability Switzerland	21

4.10 MOST ACTIVE INSTITUTION

This study includes a review of institutions’ involvement in e-learning research, specifically focusing on those that have produced a minimum of 10 publications. According to the data presented in Table 9, it can be observed that the Universidad de Salamanca has the most significant quantity of publications in the field of e-learning. Institutions from various countries, including Spain, South Africa, the Czech Republic, Indonesia, Romania, Australia, Saudi Arabia, Canada, Malaysia, Morocco, and others, reflect the global representation of e-learning research. Potential regional clusters are identified based on the number of institutions from specific countries. For example, institutions from Indonesia and Malaysia (e.g., Bina Nusantara University, Universitas Negeri Yogyakarta, Universiti Teknologi Malaysia, and Universiti Teknologi MARA) form a cluster of active contributors from Southeast Asia.

Table 9. Most active institutions

Affiliation	Documents	Affiliation	Documents
Universidad de Salamanca, Spain	24	Universiti Teknologi Malaysia, Malaysia	11
University of South Africa, South Africa	23	Université Abdelmalek Essaadi, Morocco	11
Univerzita Hradec Králové, Czech Republic	22	The University of Queensland, Australia	11
Bina Nusantara University, Indonesia	19	Universitas Negeri Yogyakarta, Indonesia	11
University Politehnica of Bucharest, Romania	15	Universiti Teknologi MARA, Malaysia	10
University of Melbourne, Australia	13	University of Toronto, Canada	10
King Khalid University, Saudi Arabia	13	KU Leuven, Belgium	10
King Saud University, Saudi Arabia	12	Universitas Negeri Malang, Indonesia	10
University of Ottawa, Canada	12		

CONCLUSION

The primary objective of this study is to perform an extensive bibliometric analysis of the existing literature in the domain of e-learning. The purpose is to gain a full understanding of the scope and depth of academic research conducted in this dynamic sector. The bibliometric analysis conducted in this research offers valuable insights into the landscape of e-learning research, focusing on keyword distribution, country representation, year of publications, and subject areas.

The increasing trend in e-learning research publications over the years demonstrates the growing importance of digital education in the academic community. This upward trajectory indicates the continuous evolution and expansion of e-learning as a critical area of investigation. The interdisciplinary nature of e-learning research across various subject areas highlights its multifaceted nature, integrating insights from fields such as Computer Science, Social Sciences, Engineering, and Medicine. This interdisciplinarity offers a broader perspective for addressing complex educational challenges and fostering innovative solutions. The global representation of e-learning research, with contributions from diverse countries, reflects the widespread interest and engagement in the field. Such diversity presents opportunities for cross-cultural collaborations, knowledge exchange, and developing contextually relevant e-learning solutions tailored to specific regions. The institutes actively involved in e-learning research make significant contributions which are crucial in pushing the boundaries of knowledge and promoting innovation within the area. These institutions are potential hubs for collaboration and knowledge exchange, driving further advancements in e-learning practices. Using Social Network Analysis to visualize co-cited authors, regions, and keywords contribute to a deeper understanding of the collaborative nature of e-learning research. The analysis of co-occurrence networks reveals clusters of related keywords, authors, and countries, emphasizing the interconnectedness and collaborative efforts within the e-learning research community. The prevalence of the keyword “e-learning” emphasizes its centrality and significance in research. It serves as a unifying term, representing the core theme of digital learning. The emergence of “Covid-19” as a prominent keyword underscores the substantial impact of the pandemic on e-learning, encouraging further exploration of how educational systems adapted to the crisis (Rahim et al., 2023).

In conclusion, the bibliometric analysis provides valuable insights into the current state of e-learning research, highlighting its central themes, global representation, and continuous growth. The findings contribute to a better understanding of the e-learning research landscape, paving the way for future research opportunities and collaborative efforts within the e-learning community. By exploring emerging trends, researchers, educators, policymakers, and institutions can collectively enhance the impact and effectiveness of e-learning, contributing to the transformation of the educational landscape in the digital era.

ACKNOWLEDGEMENTS

This research was supported by the Universiti Teknologi MARA, Cawangan Negeri Sembilan.

REFERENCES

- Abbasi, S., Ayoob, T., Malik, A., & Memon, S. I. (2020). *Perceptions of students regarding E-learning during Covid-19 at a private medical college. Pakistan Journal of Medical Sciences, 36(COVID19-S4), S57–S61. <https://doi.org/10.12669/pjms.36.COVID19-S4.2766>*
- Aboagye, E., Yawson, J. A., & Appiah, K. N. (2020). *COVID-19 and E-Learning: the Challenges of Students in Tertiary Institutions. Social Education Research, 2(1), 1–8. <https://doi.org/10.37256/ser.212021422>*
- Al-Fraihat, D., Joy, M., Masa'deh, R., & Sinclair, J. (2020). *Evaluating E-learning systems success: An empirical study. Computers in Human Behavior, 102, 67–86. <https://doi.org/https://doi.org/10.1016/j.chb.2019.08.004>*
- Almaiah, M. A., Al-Khasawneh, A., & Althunibat, A. (2020). *Exploring the critical challenges and factors influencing the E-learning system usage during COVID-19 pandemic. Education and Information Technologies, 25(6), 5261–5280. <https://doi.org/10.1007/s10639-020-10219-y>*
- Alqahtani, A. Y., & Rajkhan, A. A. (2020). *E-Learning Critical Success Factors during the COVID-19 Pandemic: A Comprehensive Analysis of E-Learning Managerial Perspectives. Education Sciences, 10(9). <https://doi.org/10.3390/educsci10090216>*

- Alsoufi, A., Alsuyihili, A., Msherghi, A., Elhadi, A., Atiyah, H., Ashini, A., Ashwieb, A., Ghula, M., Ben Hasan, H., Abudabuos, S., Alameen, H., Abokhdhir, T., Anaiba, M., Nagib, T., Shuwayyah, A., Benothman, R., Arrefae, G., Alkhwayildi, A., Alhadi, A., Elhadi, M. (2020). Impact of the COVID-19 pandemic on medical education: Medical students' knowledge, attitudes, and practices regarding electronic learning. *PLOS ONE*, 15(11), e0242905. <https://doi.org/10.1371/journal.pone.0242905>
- Brika, S. K. M., Chergui, K., Algamdi, A., Musa, A. A., & Zouaghi, R. (2021). E-Learning Research Trends in Higher Education in Light of COVID-19: A Bibliometric Analysis. *Frontiers in Psychology*, 12, 762819. <https://doi.org/10.3389/fpsyg.2021.762819>
- Butts, C. T. (2008). Social network analysis: A methodological introduction. *Asian Journal of Social Psychology*, 11(1), 13–41. <https://doi.org/10.1111/j.1467-839X.2007.00241.x>
- Candeloro, L., Savini, L., & Conte, A. (2016). A new weighted degree centrality measure: The application in an animal disease epidemic. *PLoS ONE*, 11(11), 1–14. <https://doi.org/10.1371/journal.pone.0165781>
- Castillo-Velazquez, J. I., & Silva-Lopez, R. B. (2022). Evolution and Trends in E-Learning Approaches to STEM, Engineering Education and Corporate Learning: A Bibliometric Analysis to 2021. 2022 IEEE ANDESCON: Technology and Innovation for Andean Industry, ANDESCON 2022, 2005, 1–6. <https://doi.org/10.1109/ANDESCON56260.2022.9989971>
- Chen, C. (2017). Science Mapping: A Systematic Review of the Literature. *Journal of Data and Information Science*, 2(2), 1–40. <https://doi.org/doi:10.1515/jdis-2017-0006>
- Chiroma, H., Ezugwu, A. E., Jauro, F., Al-Garadi, M. A., Abdullahi, I. N., & Shuib, L. (2020). Early survey with bibliometric analysis on machine learning approaches in controlling COVID-19 outbreaks. *PeerJ. Computer Science*, 6, e313. <https://doi.org/10.7717/peerj-cs.313>
- Favale, T., Soro, F., Trevisan, M., Drago, I., & Mellia, M. (2020). Campus traffic and e-Learning during COVID-19 pandemic. *Computer Networks*, 176, 107290. <https://doi.org/https://doi.org/10.1016/j.comnet.2020.107290>

- Gopalakrishnan, S., Sridharan, S., & Venkatraman, S. (2020). *Centrality Measures in Finding Influential Nodes for the Big-Data Network BT - Handbook of Smart Materials, Technologies, and Devices: Applications of Industry 4.0* (C. M. Hussain & P. Di Sia (eds.); pp. 1–17). Springer International Publishing. https://doi.org/10.1007/978-3-030-58675-1_103-1
- Harzing, A. W. (2007). *Publish or Perish*. <https://harzing.com/resources/publish-or-perish>
- Hasan, N., & Bao, Y. (2020). *Impact of “e-Learning crack-up” perception on psychological distress among college students during COVID-19 pandemic: A mediating role of “fear of academic year loss”*. *Children and Youth Services Review*, 118, 105355. <https://doi.org/10.1016/j.chilyouth.2020.105355>
- Jaradat, Y., Alia, M., Masoud, M., Manasrah, A., Jebreil, I., Garaibeh, A., & Al-Arasi, S. (2022). *A bibliometric analysis of the International Journal of Advances in Soft Computing and its Applications: Research influence and Contributions*. *International Journal of Advances in Soft Computing and Its Applications*, 14(2), 167–184. <https://doi.org/10.15849/IJASCA.220720.12>
- Kimura, R., Matsunaga, M., Barroga, E., & Hayashi, N. (2023). *Asynchronous e-learning with technology-enabled and enhanced training for continuing education of nurses: a scoping review*. *BMC Medical Education*, 23(1), 505. <https://doi.org/10.1186/s12909-023-04477-w>
- Law, V. T. S., Yee, H. H. L., Ng, T. K. C., & Fong, B. Y. F. (2022). *Transition from Traditional to Online Learning in Hong Kong Tertiary Educational Institutions During COVID-19 Pandemic*. *Technology, Knowledge and Learning*, 28(3), 1425–1441. <https://doi.org/10.1007/s10758-022-09603-z>
- López-Robles, J. R., Casas-Valadez, M. A., Guzmán-Fernández, A., Monjaraz-Frausto, C., Castorena-Robles, A., & Gamboa-Rosales, N. K. (2020). *Understanding the relationship between e-learning and web 2.0: A bibliometric and thematic analysis from 2006 to 2020*. *Proceedings of the International Conference on E-Learning, ICEL, 2020-December*, 290–295. <https://doi.org/10.1109/econf51404.2020.9385510>

- Mailizar, Almanthari, A., Maulina, S., & Bruce, S. (2020). Secondary school mathematics teachers' views on e-learning implementation barriers during the COVID-19 pandemic: The case of Indonesia. *Eurasia Journal of Mathematics, Science and Technology Education*, 16(7). <https://doi.org/10.29333/EJMSTE/8240>
- R.Radha Dr.V.Sathish Kumar, Dr.AR.Saravanakumar, K. M. (2020). E-Learning during Lockdown of Covid-19 Pandemic: A Global Perspective. *International Journal of Control and Automation*, 13(4 SE-Articles), 1088–1099. <http://sersec.org/journals/index.php/IJCA/article/view/26035>
- Rahim, N. Z. A., Bahari, N. N., Azzimi, N. S. M., Zamzuri, Z. H., Bahaludin, H., Mohammad, N. F., & Razak, F. A. (2023). Comparing Friends and Peer Tutors Amidst COVID-19 Using Social Network Analysis. *Mathematics*, 11(4), 1–17. <https://doi.org/10.3390/math11041053>
- Sapini, M. L., Noorani, M. S. M., Razak, F. A., Alias, M. A., & Yusof, N. M. (2022). Understanding Published Literatures on Persistent Homology using Social Network Analysis. *Malaysian Journal of Fundamental and Applied Sciences*, 18(4), 413–429. <https://doi.org/10.11113/mjfas.v18n4.2418>
- Silverstru, C. I., Ion, V., Botez (Costatin), C., & Icociu, V.-C. (2018). ISCED Classification Influence on E-Learning Education Systems. *Informatica Economica*, 22(4/2018), 80–88. <https://doi.org/10.12948/issn14531305/22.4.2018.07>
- Sreejith, R. P., Mohanraj, K., Jost, J., Saucan, E., & Samal, A. (2016). Forman curvature for complex networks. *Journal of Statistical Mechanics: Theory and Experiment*, 2016(6), 1–18. <https://doi.org/10.1088/1742-5468/2016/06/063206>
- Sweileh, W. M. (2021). Global Research Activity on E-Learning in Health Sciences Education: a Bibliometric Analysis. *Medical Science Educator*, 31(2), 765–775. <https://doi.org/10.1007/s40670-021-01254-6>
- Van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2), 523–538. <https://doi.org/10.1007/s11192-009-0146-3>