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E-learning research trends in India : A data visualization and network analysis spanning 2015-2024

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E-Learning or digital education in India has changed tremendously in the last decade. The present study used tools, techniques and software packages for analyzing and visualizing data from 2015 to 2024 on e-learning research trends in India. A total number 7,843 documents were retrieved during the study period. In this study Scopus was used as the primary data source to identify the year wise growth pattern, most influential Indian authors, emerging research areas and collaborative networks analysis. The study found that e-learning publications (1772) in India was peaked in 2023 followed by a slight decline in 2024. It also points out that research in computer science and engineering is the most dominant, but contributions from social sciences and decision sciences are also increasing. The analysis of co-authorship and co-occurrence networks highlights the importance of collaboration in sharing knowledge. Achuthan Krishnashree and Diwakar Shyam are most productive authors. The most frequently used keyword was e-learning, learning systems, and machine learning, showing the growing impact of artificial intelligence and digital learning technologies. The most-commonly chosen publication was Lecture Notes in Networks and Systems. These findings help policymakers, educators, and researchers understand gaps in research, evaluate the future of e-learning in India, and identify chances for advancements in digital education.

Keywords: *E-learning, Bibliometric analysis, Network analysis, Co-authorship, Digital learning, Online education, India, Scientometrics, Research trends.*

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1. Introduction

E-learning has become an essential component of India's education system due to the rapid growth of digital

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technologies and government initiatives promoting online learning. The introduction of major digital initiatives, like SWAYAM, DIKSHA, the National Digital Library of India (NDLI), and the PM e-VIDYA program under the National Education Policy (NEP) 2020, has significantly promoted the integration of digital learning across the school, higher education, and lifelong learning sectors. These resources promote students learning outcomes, user's development, educator awareness, and accessibility barriers in varied educational contexts. Over the last decade, studies on e-learning in India has grown significantly, especially during and after the COVID-19 pandemic when online learning became the primary way to gain knowledge. This change has prompted a wide range of academic research on topics such as digital education, student engagement, curriculum development, classroom competency, smartphone and tablet adoption, MOOCs, virtual and blended learning strategies, and the use of new technologies, including artificial intelligence, learning analytics, and immersive environments. In the modern education system, the concept of e-learning as a seamless way for accessibility of knowledge and education has spread across the world. Other government initiatives like NPTEL, Digital India, SWAYAM etc. are best known for the expansion of online accelerated learning processes for higher education, which is a new paradigm in the education system. Post the pandemic situation in India, e-learning platforms have become an integral part of the daily curriculum of education, which has been a great evolution for exploring teaching methods, implementing academic research.

In recent years, scientific output has become a critical metric for the activity of a nation's scientific community, attracting the attention of policymakers at both national and international levels. Many research and development (R&D) decisions are heavily influenced by scientific production, even though it cannot be regarded as a sole indicator of overall scientific growth and development. Due to its dynamic nature and strong links with technological and scientific progress, e-learning has emerged as a significant field of scientific study. The rapid evolution of technology, combined with the unprecedented impact of the COVID-19 pandemic, has significantly transformed India's educational landscape. E-Learning, once considered a supplementary mode of education, has emerged as an important component of the learning infrastructure, particularly during and after the pandemic. From 2020 to 2024, there was an increase in research aimed at understanding, implementing, and optimizing e-learning solutions to address the challenges and opportunities presented by this shift. This study explores the core body of research on e-learning in India, where we seek to visualize trends through network analysis. The impact of Indian researchers on e-learning has been explored in terms of authors, keywords, sources, etc.

COVID-19 prompted educators, policymakers and researchers to rethink traditional approaches to pedagogy and accelerate the adoption of digital learning platforms. During the temporary closure of schools, colleges, and universities, e-learning became the primary education delivery method. A country with a diverse population and limited resources, like India, experienced a sudden transition in digital education. The research conducted

during this period has focused on multiple related topics, including, but not limited to, technology integration, accessibility, and student engagement.

Table 1

Evolution of E-Learning: Early Teaching Machines to AI-Driven Digital Learning

Era	Year	Key Milestone
i. Early Foundations (1920s-1970s)	1924	An early teaching machine was invented by Sidney Pressey (Automatic Teacher).
	1954	The idea of self-paced learning with immediate feedback was introduced by B.F. Skinner through programmed instruction.
	1960	An interactive computer-based learning system called PLATO was developed at the University of Illinois.
ii. The Rise of Personal Computers (1980s)	1980s	The introduction of computer-based training (CBT) using CD-ROMs and personal computers.
	1984	Computers became more accessible through Apple's Macintosh.
	1989	World Wide Web inventor Tim Berners-Lee laid the foundations for online learning.
iii. The Internet Era (1990s)	1994	Universities provide online courses, marking the start of internet-based education.
	1999	The term "e-learning" gained popularity as Learning Management Systems (LMS) like Blackboard and WebCT emerged.
iv. The 2000s: Expansion and Innovation	2002	MIT OpenCourseWare made educational resources freely available online.
	2006	YouTube revolutionized video-based learning.
	2008	The first MOOCs (Massive Open Online Courses) were introduced, democratizing access to education globally.
v. The 2010s: Mobile Learning and Gamification	2010	The rise of smartphones enabled mobile learning, allowing learners to access content anytime, anywhere.
	2012	Gamification techniques, such as badges and leaderboards, were integrated into e-learning platforms to boost engagement.
	2015	AI-driven adaptive learning systems personalized education based on the needs of individual learners.
vi. The 2020s: Pandemic-Driven Transformation	2020	The COVID-19 pandemic accelerated the adoption of e-learning, making it the primary mode of education globally.
	2021	Hybrid learning models, combining online and in-person instruction, gained traction.
	2022-2024	Advances in AI, VR, and AR are making e-learning more interactive and immersive.

2. History and Development of E-Learning

E-learning, or electronic learning, has evolved significantly over the decades, driven by technological advancements and the growing need for accessible, scalable, and flexible education. The table 1 summarizes the progressive development of e-learning from early mechanical teaching aids to advanced digital ecosystems. It begins with foundational ideas of automated and self-paced learning in the mid-20th century, advances through the personal computer and internet revolutions that enabled computer-based training and online courses, and expands in the 2000s with open resources, video learning, and MOOCs. The 2010s emphasize mobile access, gamification, and AI-driven personalization, while the 2020s highlight pandemic-led mass adoption, hybrid learning models, and the integration of immersive technologies such as AI, VR, and AR.

3. Literature Review

Existing literature highlights the interdisciplinary and collaborative nature of e-learning research, particularly in the Indian context. Gupta and Mishra emphasize the growing convergence of education, information science, and technology in Indian e-learning studies, underscoring the importance of cross-disciplinary collaboration for research impact [1]. Complementing this view, Singh and Kumar demonstrate that high-impact researchers play a crucial role in knowledge diffusion within e-learning networks, shaping research visibility and citation patterns [2]. From a pedagogical perspective, Bates provides practical guidelines for designing effective digital learning environments, stressing learner-centered approaches and the strategic use of technology [3]. Empirical evidence supporting such designs is presented by Means et al., whose meta-analysis confirms that online and blended learning can be as effective as, or more effective than, traditional face-to-face instruction when properly implemented [4]. Bibliometric insights by Mitra and Banerjee reveal dominant keywords and evolving research themes in Indian e-learning literature between 2015 and 2024, indicating a shift toward analytics-driven and learner-personalized systems [5]. The traditional education system is being replaced by various modern education methods which are being effectively promoted through various digital education platforms to deploy problem solvers for smooth learning process.

Trending data analysis tools are very helpful in finding influential information with current perspectives on any research field. For this purpose, Gupta and Sharma [6] mention bibliometric and network building methods to find leading authors through their collaborative networks and original research with thematic value in a particular study. In 2021, Negahban [7] conducted a network analysis and presented a scientific map of e-learning research in Iran, with an emphasis on the identification of emerging and prominent subject areas. Sharma, Verma, and Gupta [8] in their paper discuss the impact of e-learning in various sectors and they show that technical sectors are highly influential for these aspects. They found an increasing annual trend in e-learning publications, with high-frequency keywords such as e-learning, education, technology, system, and satisfaction representing active and emerging concepts. [9]. Along with the advancement

of ICT, Gupta and Singh [10] have emphasized ethical, designing lessons, and intellectual research as additional facets of e-learning education. Data were extracted from the Web of Science database, formatted using WC10.exe, and visualized using VOSviewer. E-learning has increased during or after COVID-19, which has also had a great impact on the aura of publications and new research areas [11]. The research examines the co-occurrence network of e-learning using scientometric methods and citation analysis, with a focus on the centrality measures closeness and betweenness [12]. Clark and Mayer provide proven guidelines for consumers and designers of multimedia learning in digital education environments [13]. Kumar, Sharma, and Bose discuss MOOCs and blended learning as transforming digital education in India [14]. Singh and Mehta [15] examined the impact of different disciplines on e-learning, where they found that the most focused field was computer science and the least focused field was social sciences. The most prominent subject areas were e-learning and education, while topics such as learning, technology, and system learning exhibited high centrality and influence [16]. Mishra and Gupta highlight funding and policy support for e-learning research in India [17]. Nair, Rao, and Krishnan provide a bibliometric insight into leading contributors to e-learning research in India [18]. Rai and Mukherjee [19] take a different perspective on e-learning research, incorporating metric studies, suggesting that their research should focus on creative learning approaches rather than relying solely on online learning. In their paper, Rai and Verma [20] analyzed ten years of data on Indian research on e-learning to understand the current state of online education through a bibliometric study. E-learning has increased during or after COVID-19, which has also had a great impact on the aura of publications and new research areas [21]. Mishra and Patel analyze the rise and decline of e-learning research in India through bibliometric analysis [22]. While the value of trending topics fluctuated based on research aspects, last year's market data showed a trending trend [29]. Another hot topic is AI which is having a great impact on every field, especially in this era when it comes to e-learning [23]. A study of Indian research networks on e-learning shows the gap between everyday education systems and real-life implementation [19]. The main research findings in the study of e-learning are based on artificial intelligence and digital learning methods, which are undoubtedly changing the landscape of Indian education [15]. Thus, finding the gap in Indian research on global digital education systems offers a new way to approach modern education.

4. Objectives of the Study

The objectives of the present study are listed below -

1. Is scientific output in India growing in the area of e-learning?
2. Is there a high demand for e-learning in India? If so, what are the most popular and emerging subjects?
3. Who are the most influential Indian authors on the subject of e-learning?
4. How does the centrality measure, closeness, influence the dissemination of research in e-learning studies in co-authorship networks?

5. Is the co-occurrence network based on the centrality measure of closeness in e-learning?

5. Research Methodology

Design and scope of the study: data were collected from Scopus covering a period of 10 years from January 2015 to December 2024. This time period was chosen specifically because it highlights a significant shift in India's digital education landscape, beginning with the rise of national digital initiatives and continuing with the rapid growth of online education during and after the COVID-19 pandemic. These years represent both the initial years of government-supported e-learning platforms (such as SWAYAM, DIKSHA, and NDLI) and the rapid development period when institutions shifted to technology-enabled learning on a large scale [28]. As a result, this timeframe provides an accurate representation of the topic's evolving research interests. Bibliometric analysis tools were used to determine and characterize the research output of the sample. Only conference papers, articles, book chapters, and review papers were included. Other document types such as letters, editorials, notes, and erratum were excluded.

5.1 *Data Collection*

The study used Scopus, a renowned interdisciplinary citation database. Scopus is one of the largest abstracts- and citation-based databases, indexing a large number of peer-reviewed journals covering subject fields across the social sciences, physical sciences, life sciences, and health sciences. An advanced search strategy was used to retrieve publication data from Scopus. The search strategy comprised entering the key words, and limiting the date range from 2015 to 2024.

The search strategy (Figure 1) was as follows:

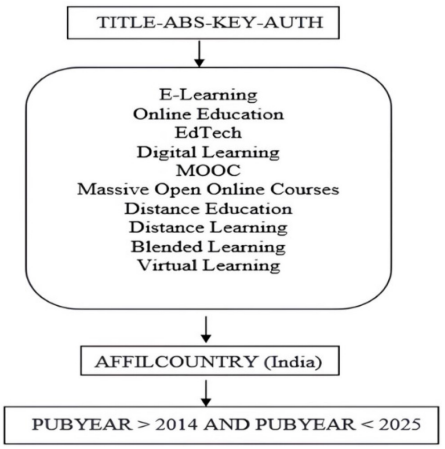


Figure 1

Search Strategy for Data Collection from Scopus Database

The search was performed on 1st March 2025. Using the above search strategy, the data were collated into a single Microsoft Excel spreadsheet. A total of 7,843 unique sources were found in the Scopus database, including journal articles, conference papers, book chapters, and reviews. All records were downloaded with complete bibliographic details and exported in CSV (comma separated values) format, before being further organized and analyzed using Advanced Microsoft Excel tools, Vos viewer, and R software.

5.2 *Data Analysis*

Data were cleaned, and unwanted data were removed. Data were analyzed using a Bibliometric R package, VOSviewer and Microsoft Excel. A total of 7,843 document records published during the study period.

6. Analysis and Discussion

The demand for e-learning in India, as reflected in the bibliometric data from 2015 to 2024, shows significant research activity, with 7,843 documents published across 2,765 sources. However, the annual growth rate of -38.2% suggests a decline in the number of new publications in recent years. Despite this, the average number of citations per document (7.3) indicates a sustained academic interest in previously published works. The high number of conference papers (3,927) and journal articles (3,022) highlights the dominance of e-learning discussions in academic and professional forums. The extensive use of Keywords Plus (24,308) and Author's Keywords (17,090) suggests a diverse and evolving research focus. With 18,155 authors contributing, collaboration is evident, particularly with a co-authorship rate of 3.6 per document and 17.5% international co-authorship, reflecting a global engagement with India's e-learning research. These findings indicate that while research output has declined recently, e-learning remains a significant and multidisciplinary field of study, with substantial collaboration and ongoing scholarly impact.

6.1 *Scientific output in India growing in the area of e-learning*

The Figure 2 illustrates the growth of e-learning research publications in India from 2015 to 2024, showing a significant upward trend. Initially, the number of articles published increased gradually from 244 in 2015 to 542 in 2020. However, a sharp surge is observed in 2021, with publications nearly doubling to 1,019, followed by a peak in 2023 at 1,772. While 2024 shows a slight decline to 1,417, the overall trend indicates a strong and growing research interest in e-learning over the past decade, reflecting India's increasing emphasis on digital education and online learning platforms.



Figure 2

Number of articles published in e-learning research in India, 2015 - 2024

6.2 *Evolving Subject Areas*

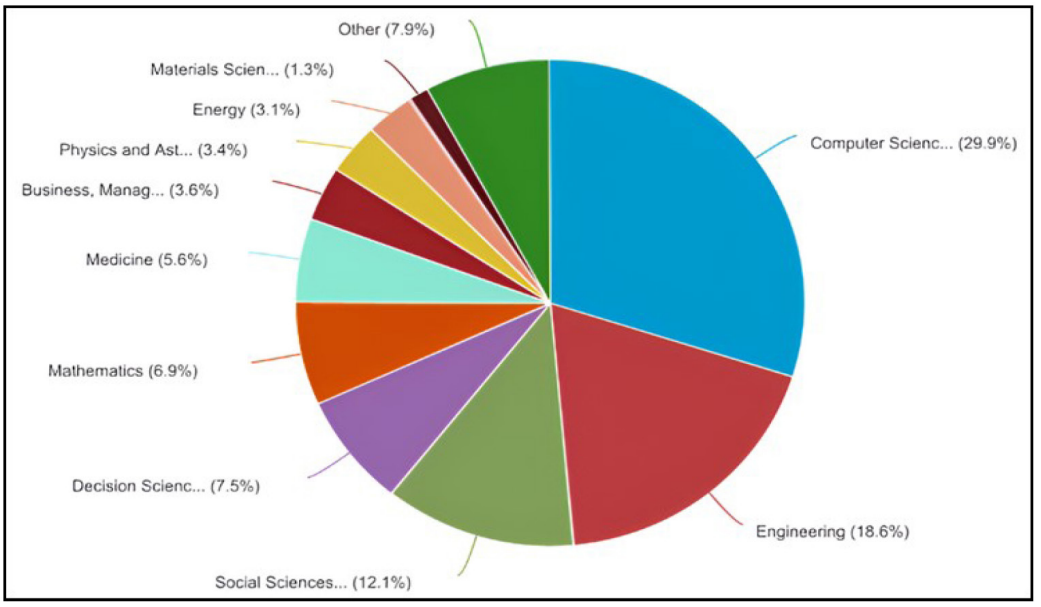


Figure 3

Subject areas represented in e-learning research in India, 2015 - 2024

The analysis of research output in e-learning across various subject areas in India from 2015 to 2024 in figure 3, reveals that Computer Science (29.9%) leads as the most dominant field, followed by Engineering (18.6%), reflecting its technological foundation. Social Sciences (12.1%) highlight pedagogical studies, while Decision Sciences (7.5%) and Mathematics (6.9%) focus on data-driven learning. Medicine (5.6%) shows growth in online medical education, and Business & Management (3.6%) explores corporate e-learning. Other contributions from Physics (3.4%), Energy (3.1%), and Materials Science (1.3%) indicate specialized applications, with 7.9% spanning interdisciplinary areas.

6.3 *Most influential Indian authors*

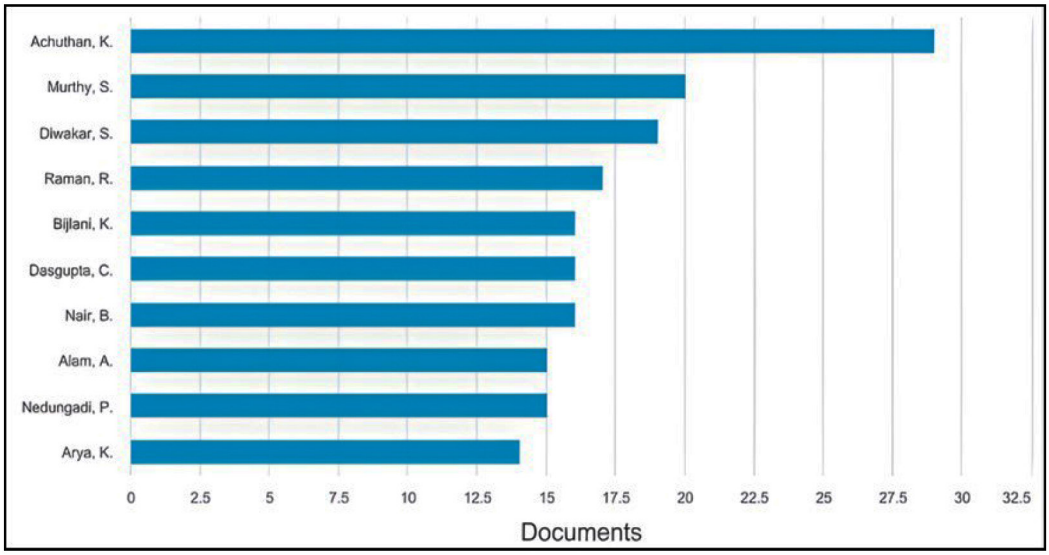


Figure 4

Frequency of publications by the most influential authors

Among the top 15 authors, Achuthan, Murthy, and Diwakar emerged as the leading contributors, consistently publishing a significant number of papers on digital learning and educational technology (see Figure 4). Raman and Bijlani. also demonstrated a strong research presence, reflecting their active engagement in e-learning innovations. Scholars like Dasgupta, Nair, and Alam contributed substantially to interdisciplinary applications of e-learning, while Nedungadi and Arya focused on emerging areas like MOOCs and blended learnin-g. The analysis highlights a diverse group of researchers shaping India's e-learning landscape, emphasizing the growing academic interest in this field over the past decade.

6.4 *Key Journals for Publishing*

Table 2

Key Journals for Publishing

SL No	Journal Title	Publishers	No. of Publications	Journal Impact Factor	SJR
1	Lecture Notes in Networks and Systems	Springer International	335	0.616	0.166
2	Journal of Engineering Education Transformations	Rajarambapu Institute of Technology	158	1.375	0.317
3	Lecture Notes in Electrical Engineering	Springer Verlag	136	0.357	0.143
4	AIP Conference Proceedings	American Institute of Physics	115	0.372	0.153
5	ACM International Conference Proceeding Series	Association for Computing Machinery	95	1.142	0.191
6	Smart Innovation, Systems and Technologies	Springer Science and Business	85	0.507	0.163
7	Education and Information Technologies	Kluwer Academic	73	8.995	1.654
8	Multimedia Tools and Applications	Springer	73	5.195	0.777
9	IEEE Access	IEEE	71	5.31	0.849
10	Communications in Computer and Information Science	Springer Science and Business	67	0.584	0.182

Table 2 illustrates the most key journals for publishing research papers between 2015 to 2024. The most-commonly chosen publication was Lecture Notes in Networks and Systems, with 335 papers and an impact factor of 0.616, followed by Journal of Engineering Education Transformations, with 158 papers an impact factor of 1.375, Lecture Notes in Electrical Engineering with 136 papers and an impact factor of 0.357.

6.5 *Co-authorship networks influence the dissemination of research in e-learning studies*

The co-authorship network (Figure 5) in e-learning research plays a crucial role in the dissemination of knowledge. This is highlighted by the total link strength of the top Indian researchers in the field. Achuthan (70), Diwakar (68), and Nair (65) exhibit the highest link strengths, indicating their significant collaborative influence in advancing digital learning research. These authors, with substantial publications and citations, serve as key connectors, fostering interdisciplinary collaborations that enhance both research visibility and impact.

Other notable contributors, such as Kumar (57), Nizar (48), and Radhamani (47), also demonstrate significant co-authorship networks, further reinforcing the collaborative nature of e-learning studies in India. The data suggest that highly interconnected authors accelerate knowledge diffusion, shape emerging research trends, and contribute to the development of innovative educational technologies.

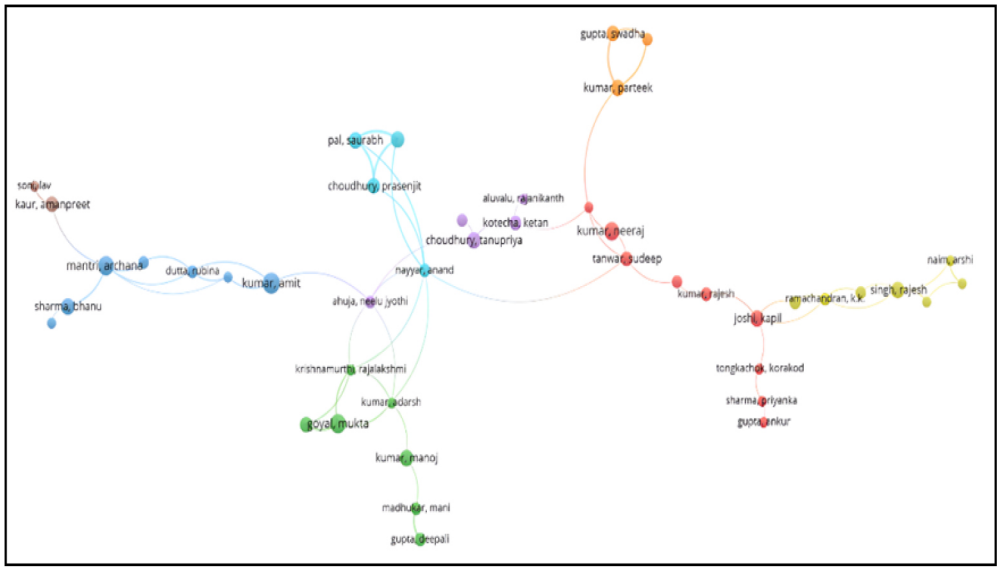


Figure 5

Co-authorship network of publications in e-learning research in India

6.6 *Co-occurrence network based on e-learning's closeness centrality measure*

The co-occurrence network analysis (Figure 6) of e-learning research in India from 2015 to 2024, based on the closeness centrality measure, reveals a highly interconnected structure of 3,083 significant keywords out of a total of 33,510 keywords. The network includes 1,000 selected keywords, forming multiple clusters. The top-ranked keywords based on link strength are:

E-learning	: 5,235 occurrences,	link strength of 43,560
Learning systems	: 1,766 occurrences,	link strength of 17,390
Machine learning	: 1,303 occurrences,	link strength of 13,096

In this science map, keywords with higher closeness centrality, such as e-learning, learning systems, and machine learning, demonstrate greater influence, indicating their central role in the landscape of e-learning research in India. These nodes act as key connectors between various research themes and disciplines. On the other hand, lower-ranked keywords like "education" and "teaching," despite being relevant, show relatively

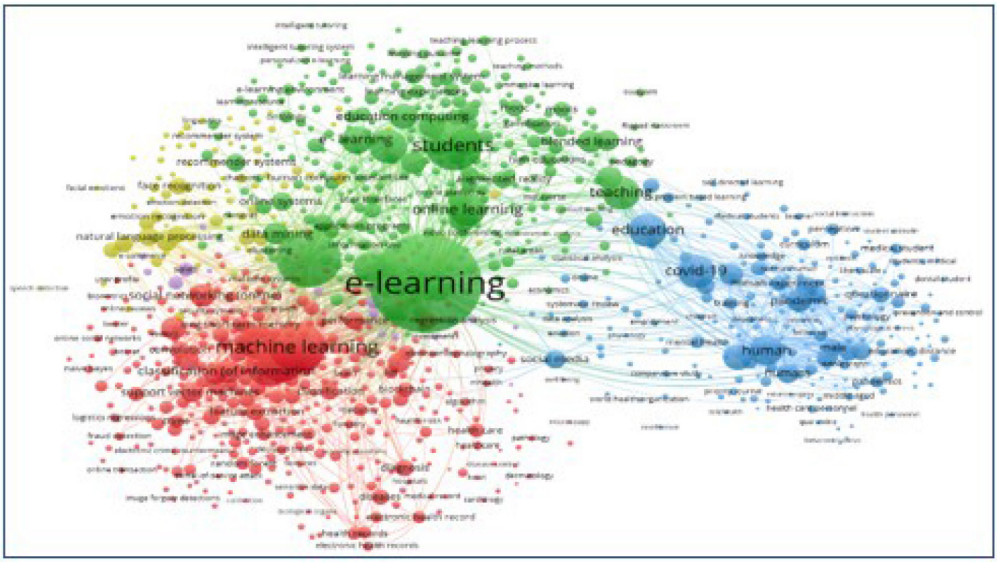


Figure 6

Co-occurrence network based on the centrality measure, closeness, of publications

weaker connectivity. This suggests that they function more as supporting concepts rather than as central themes in the evolving e-learning research network. The results highlight the significance of AI-driven learning methods, student engagement strategies, and digital learning systems in shaping the future of e-learning research in India.

7. Conclusion

This study shows a significant increase in Indian e-learning research during or after the COVID situation. On the other hand, previous research on e-learning lacks quality, diversity, and some informative concepts. In this study, we investigated whether Indian e-learning research has improved in scientific research and found that e-learning research output in India reached its highest level in 2023. Important research areas such as computer science, AI, hybrid learning, etc. become core areas of the network of Indian authors that will be the new paradigm of modern education. In this study, the analysis of co-authorship and keywords in e-learning research points the way for a centralized approach in determining sharing. This is why it is necessary to achieve adequate funding, policy and institutional support for the dissemination of e-learning related research in India. On the other hand, it should be essential to empower policymakers to further enhance the educational, technical, and social sciences through encouragement of e-learning implementation. This analytical study looks at the impact of e-learning research in India with a few limitations; Scopus is the only database used in this study to cover the research areas of e-learning.

For the promotion of education, e-learning, along with the concept of open access, has a valuable impact on the global education culture. We have shown in our study that e-learning research in India is becoming the most growing transformation of the modern education system. There is no doubt that the concept of Digital India initiative is being enriched by the successful implementation of e-learning.

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