

E-learning Research in India: A Bibliometric Analysis of Research Production

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ABSTRACT:

The paper gives a statistical evaluation of Indian authors' research output in the e-learning field (3243 publications). The information was obtained from the Scopus database between 2010 and 2021. According to the study, worldwide e-learning research grew at a rate of 20.9 percent every year on average. A total of 7052 authors contributed to e-learning research. Anna University (92 papers) is India's most producing organisation, while Amrita University is the most cited. Bijlani K. (22 papers) is the most prolific author, and Nedungadi P. is the most cited author. On a worldwide basis, these Indian authors have a significant scientific relationship with the United States. The most popular source for publishing on this topic was *ACM International Conference Proceeding Series*.

Keywords: E-learning, Electronic learning, Bibliometrics, Scopus, VOSviewer.

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INTRODUCTION

In addition to the traditional classroom education system, electronic learning has grown as a strong digital education platform that provides new possibilities for delivering formal and informal learning and education. Over time, e-learning terminology has evolved from online, computer-based, web-based, internet-based and virtual classrooms to digital teamwork.[1] The global spread of e-learning systems has been accelerated by advances in computer and internet technologies. E-learning management systems are intended to offer and manage training or educational information to learners, make the learning process more active and efficient, and enable them to study at their own speed in real-time and interactively. E-learning activities nowadays take place in virtual classrooms, allowing students to select from various material arrangements. E-learning technologies expanded education throughout traditional classrooms, created new opportunities for ambitious students and workers, facilitated competency-based learning, and radically revolutionised how teaching is typically done in the higher education

segment. E-learning research has resulted in the expansion and development of e-content contributors, certification organisations, and e-learning technologies worldwide, resulting in a vast and expanding e-learning sector on a domestic and global scale.

In the current study, the author employed the bibliometric method to examine the concepts of literature on *e-learning* from 2010 to 2021, intending to offer a better insight into studies. In contrast, several scholars (Tibaná-Herrera *et al.*^[2-3] Fatima and Abu,^[4] Gupta and Pandey,^[5] Gupta and Dhawan,^[1] and Das)^[6] have already attempted studies to identify research trends, even though the current study differs from their study objectives, time frame, and method used.

LITERATURE REVIEW

Tibaná-Herrera *et al.*^[2] examined *e-learning* production from 2003 to 2016 and compared it to data output from additional domains in order to determine the proportional evolution of e-learning research across nations. In 2018, Tibaná-Herrera *et al.*^[3] defined e-learning as an evolving subject in the global scientific publishing system, with periodicals and conference proceedings. The data was obtained from Scopus and covered the years 2012 to 2014. Fatima and Abu^[4] obtained bibliographical records for *e-learning* documents from the Web of Science covering 1989-2018. They examined data

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to determine major nations, authorship, collaboration index, preferred sources for research publishing, visibility of research in terms of citations obtained and citations per publication. Gupta and Pandey^[5] sought an overview of publishing patterns of Indian *e-learning* research from 2009 to 2018. The data set, which included 8181 articles, was analysed using measures such as growth rate, most productive authors, highly productive organisations, highly-cited papers and citation profile. Gupta and Dhawan^[1] examined the global production of e-learning publications. They obtained information on 1809 articles from the Scopus database between 2003 and 2018. According to the report, worldwide e-learning research grew at an annual rate of 18.92% and averaged 6.90 citations per manuscript. The top fifteen writers provided 7.89% worldwide publication shares and 33.45% global citation shares, respectively. Das^[6] mapped e-learning developments from 1970 based on bibliometric indicators, and they collected bibliometric data from the Scopus database to determine the most cited, prolific writers and the leading institutions and nations of the journal.

Similarly, the primary goal of this study is to assess e-learning research production using bibliometric indicators.

OBJECTIVES

The primary study objectives are the following:

- To study the publication growth and impact of research output
- To examine the pattern of authorship and collaborative measures.
- To find the core sources preferred by researchers.
- To know the most occurring author's keywords.
- To determine the major research themes.

MATERIALS AND METHODS

The current study intends to measure the research output of literature on '*e-learning*'. The bibliometric analysis method has been employed to evaluate the research productivity from 2010 to 2021. This method includes quantitative measurement of scholarly research, publishing trends, prolific authors, country, organisation, etc. Scopus^[7] database was chosen for its broad coverage, and the data was retrieved using the advanced search tag. The string used to extract data is given as follows:

TITLE-ABS-KEY ("e-learning" OR "e learning" OR "electronic learning" OR "elearning") AND (LIMIT-TO (AFFILCOUNTRY, "India")) AND (LIMIT-TO (PUBYEAR, 2010-2021))

A total of 3243 documents were retrieved and downloaded in the csv format. Various bibliometric indicators were used to analyse the data to fulfil the research objectives; data was processed using the Biblioshiny from the R-bibliometrix package,^[8] and VOSviewer^[9] software was used to visualise the citation graph.

DATA ANALYSIS AND DISCUSSION

Annual Publication Growth

Table 1 depicts the annual evolution of records on the topic of *e-learning*. During the twelve years between 2010-2021, a total of 3243 papers were published by Indian authors and gained 12802 citations with a 20.9% annual growth rate. The maximum number of 734 publications were published in 2021, followed by 2020 and 2019, 442 and 413 papers. The minimum number of papers (34) was published in 2010. The average per paper citation was highest in 2010 (10.23), followed by 2015 (6.51). One can see the research growth in a four-year block period. During 2010-13, only 493 were published. In the next block during 2014-17, it doubled with 860 publications; in the last block between 2018-21, it increased to 1890 documents. The average citation was observed at 5.1 during the study period. Figure 1 illustrates publication and citation annual growth parallelly.

Form-wise Distribution

Research publications were published in many formats during the study time. A maximum number of records were published in conference proceedings, followed by journal articles. Table 2 lists the various types of publications.

Table 1: Annual publication growth and Citation received.

Period	NP	TC	AC50	CPP	<i>h</i> -index
2010	91	931	2	10.23	13
2011	96	476	1	4.96	9
2012	168	1046	3	6.23	16
2013	138	761	1	5.51	13
2014	153	831	2	5.43	15
2015	220	1433	3	6.51	19
2016	250	1112	2	4.45	17
2017	237	1313	2	5.54	18
2018	301	1425	5	4.73	19
2019	413	1397	2	3.38	21
2020	442	1520	7	3.44	21
2021	734	557	-	0.76	14
2010-13	493	3214	7	6.52	
2014-17	860	4689	9	5.45	
2018-21	1890	4899	14	2.59	

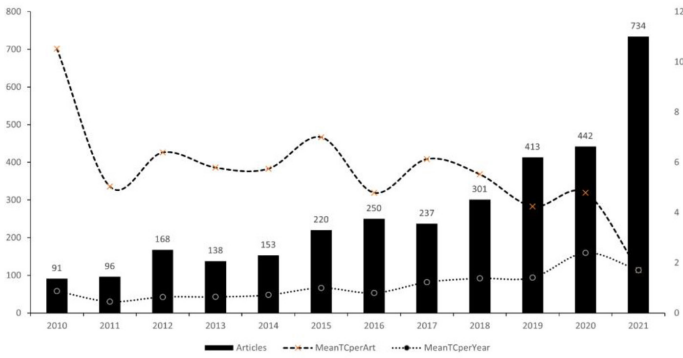


Figure 1: Annual growth vs Citation received.

Table 2: Form-wise distribution.

Publication Type	NP	TC	CPP	h-index	AC ₅₀
Conference Paper	1797	5383	3.00	25	8
Article	1165	6436	5.52	36	17
Book Chapter	150	195	1.30	8	0
Reviews	58	463	7.98	13	2
Letters	38	168	4.42	6	1
Others	35	159	4.54	6	2
Total	3243				

Table 3: Collaborative Institutions.

Name	NP	TC	h-index	AC ₅₀
Anna University	92	485	11	1
Amrita University	90	593	14	1
Vellore Institute of Technology	66	451	12	3
IIT Bombay	63	178	8	-
Amity University	51	211	9	1
University of Delhi	46	240	9	-
IIT Kharagpur	44	222	9	-
Amrita Vishwa Vidyapeetham	43	252	10	-
Sathyabama Institute of Science and Technology	40	114	7	-
IIT Delhi	36	160	7	1

Research Collaboration

Table 3 highlights the top Indian institutions that contributed the most publications in e-learning literature. Anna University is the top one with 92 papers and the second top institute is Amrita University. The ranking followed by Vellore Institute of Technology (NP=66; TC=451; h-index=12), IIT Bombay (NP=63; TC=178; h-index=8), Amity University (NP=66; TC=451; h-index=12), and Delhi University (NP=66; TC=451; h-index=12).

A graph of country-wise research collaboration is also displayed in Figure 2. Indian authors have joint publications with many countries. The United States is in the first position

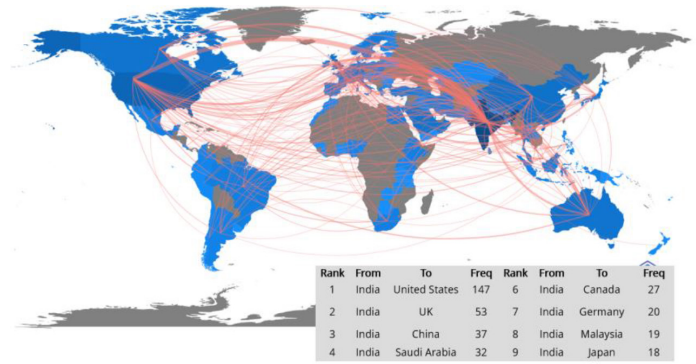


Figure 2: Country-wise research collaboration.

in this list with 147 documents. Next are the United Kingdom (NP=53), China (NP=37), Saudi Arabia (NP=32) and Canada (NP=27).

Preferred Sources for Publication

The authors published their articles in many periodicals and conferences. In Table 4, the top ten sources for research communication preferred by researchers are listed. These sources covered 15.23% of the total documents. The author's most preferred channel for scholarly communication is the "ACM International Conference Proceeding Series", in which 111 papers have appeared. The following source, "Advances in Intelligent Systems and Computing", published 108 articles. The following most preferred journals are "Lecture Notes in Computer Science" (46 papers), "Communications in Computer and Information Science" (45 papers), and "Procedia Computer Science" (39 papers). The cite per item ratio was seen highest (12.38) for the *Procedia Computer Science*, followed by the *International Journal of Innovative Technology and Exploring Eng.* (CPP=4.60). The highest h-index for the papers published in the *Procedia Computer Science* is 13, followed by *ACM International Conference Proceeding Series* (h-index=10).

Most Prolific Authors

By focusing on research production, Bijlani K. is the most productive author with 22 papers, followed by Achuthan K., Goyal M., Hariharan B. with 18 publications, Nedungadi P. with 16 records and Khamparia A., Raman R. with 15 papers. Diwakar S. and Pandey B. published 14 papers each. Chatterjee R. Choudhury P., Kolekar S. V., and Pal S. produced 12 papers each. Nedungadi P. ranked first in citations and Bijlani K. in maximum contributions. Table 5 displays the top 10 most productive authors.

Authorship Pattern and Collaborative Measures

The annual structure of the authorship pattern is shown in Table 6. It is revealed that two authors authored the maximum number of publications. In the present study, the highest value of collaboration degree (DC) observed in 2020 is 0.939,

Table 4: Preferred Sources.

Name	NP	TC	CPP	h-index	CiteScore ₍₂₀₂₁₎	SJR ₍₂₀₂₁₎
ACM International Conference Proceeding Series	111	417	3.76	10	1.0	0.232
Advances in Intelligent Systems and Computing	108	218	2.02	7	-	0.215
Lecture Notes in Computer Science	46	93	2.02	6	2.1	0.407
Communications in Computer and Information Science	45	35	0.78	4	0.9	0.209
Procedia Computer Science	39	483	12.38	13	3.6	0.569
International Journal of Applied Engineering Research	34	33	0.97	3	-	-
Library Philosophy and Practice	33	30	0.91	3	-	-
Lecture Notes in Electrical Engineering	29	30	1.03	2	0.6	0.148
International Journal of Innovative Techno. and Exploring Eng.	25	115	4.60	4	-	-
Smart Innovation Systems and Technologies	24	58	2.42	4	1.1	0.224

Table 5: Prolific Authors.

Name	NP	TC	h-index	g-index	m-index
Bijlani K.	22	156	8	11	0.615
Achuthan K.	18	175	7	13	0.538
Goyal M.	18	48	4	6	0.364
Hariharan B.	18	66	5	7	0.455
Nedungadi P.	16	245	8	15	0.615
Khamparia A.	15	120	7	10	0.778
Raman R.	15	226	7	15	0.538
Diwakar S.	14	153	6	12	0.462
Pandey B.	14	105	6	10	0.667
Roy S.	13	114	6	9	0.462
Yadav D.	13	39	4	5	0.364
Chatterjee R.	12	13	2	2	0.250
Choudhury P.	12	61	4	7	0.400
Kolekar S. V.	12	147	5	12	0.385
Pal S.	12	66	4	7	0.400

Table 6: Authorship Pattern and Collaborative Indicators.

Year	1	2	3	4	5	≥ 6	Total	CC	CI	DC
2010	18	32	24	10	5	2	91	0.496	2.538	0.802
2011	9	45	24	13	2	3	96	0.545	2.615	0.906
2012	23	68	47	14	9	7	168	0.529	2.637	0.863
2013	12	56	37	18	6	9	138	0.569	2.833	0.913
2014	15	61	34	22	12	9	153	0.567	2.882	0.902
2015	18	106	49	18	13	16	220	0.559	2.773	0.918
2016	20	102	67	36	13	12	250	0.572	2.824	0.920
2017	15	95	55	44	15	13	237	0.591	2.949	0.937
2018	31	118	81	42	17	12	301	0.558	2.774	0.897
2019	26	154	102	76	23	32	413	0.598	3.029	0.937
2020	27	158	100	77	33	47	442	0.609	3.163	0.939
2021	52	180	180	141	91	90	734	0.632	3.421	0.929

followed by 2017 and 2019 (0.937), 2021 (0.929), 2016 (0.920) and lowest value in 2010 (0.802). The highest value of the collaboration index (CI) was observed in 2021 (3.421) and the lowest (2.538) in 2010. The highest collaborative coefficient (CC) value was observed for 2021, which was 0.632; 0.609 in 2020 and 0.598 in 2019. The lowest value was 0.496, noted in the year 2010.

Most Cited Papers and Citation Profile

The citation profile of 3243 publications is displayed in Table 7. It was found that others cited 65.16% of the total publications, and 34.84% remain uncited. Furthermore, six papers (0.19%) received more than one hundred citations, 24 (0.74%) ranges between 51 to 100, 12 (0.37%) received between 41 to 50, and 1386 documents (42.74%) received citations between 1 to 5.

A list of the top ten most cited documents is made in Table 8. It was observed that all of these papers were published in various sources. These ten papers received a total of 1546 citations. The paper authored by Chechik *et al.* (2010), “Large scale online learning of image similarity through ranking”, received 461 citations and was published in the *Journal of Machine Learning Research*.

Table 7: Citation Impact.

Citation Range	NP	NP (%)	TC	TC (%)
Uncited	1130	34.84	-	-
1-5	1386	42.74	3150	20.77
6-10	383	11.81	2897	19.10
11-20	196	6.04	2862	18.87
21-30	74	2.28	1831	12.07
31-40	32	0.99	1123	7.40
41-50	12	0.37	542	3.57
51-100	24	0.74	1550	10.22
≥ 100	6	0.19	1214	8.00
Total	3243		15169	

Table 8: Most Cited Papers.

Author	DOIs	Source	TC	TCpY
Chechik G, 2010	<i>Large scale online learning of image similarity through ranking</i>	J Mach Learn Res	461	35.46
Kapasia N, 2020	10.1016/j.childyouth.2020.105194	Child Youth Serv Rev	195	65
Singh R, 2015	10.1016/j.eswa.2015.07.015	Expert Sys Appl	169	21.13
Panigrahi R, 2018	10.1016/j.ijinfomgt.2018.05.005	Int J Inf Manage	165	33
Aher SB, 2013	10.1016/j.knosys.2013.04.015	Knowl Based Syst	120	12
Rani M, 2015	10.1016/j.knosys.2015.10.002	Knowl Based Syst	104	13
Wang T, 2020	10.1109/TII.2019.2938861	IEEE Trans Ind Inf	96	32
Sasikumar CS, 2019	10.35940/ijitee.J9917.0881019	Int J Innov Technol Explor Eng	87	21.75
Yang D, 2018	10.1016/j.procs.2017.12.003	Procedia Comput Sci	76	15.2
Agarwal S, 2020	10.1007/s12098-020-03327-7	Indian J Pediatr	73	24.33
Total Citations of Highly Cited Papers			1546	

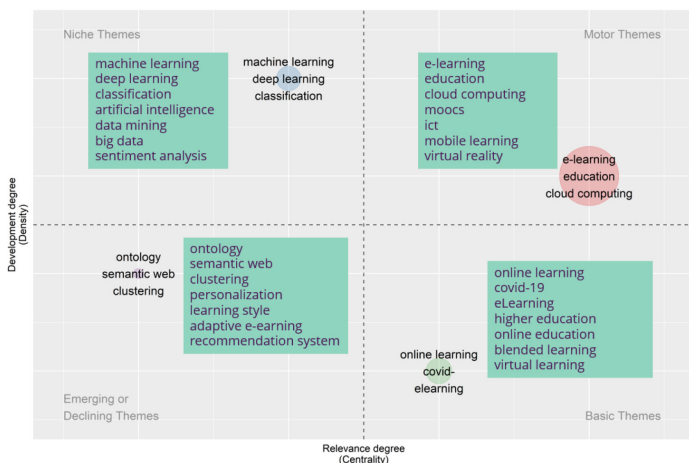


Figure 3: Thematic Map.

Thematic Map of Publications

Figure 3 visualises four themes of centrality and density with a thematic map. 175 words were selected to draw the plot with five cluster levels.

1. *The motor theme is e-learning*, shown in cluster 1. This cluster contains keywords: e-learning, education, cloud computing, moocs, ict, mobile learning and virtual reality etc.
2. *The basic theme is online learning*, represented by cluster 2. This cluster consists of online learning, covid-19, eLearning, higher education, online education, blended learning, and virtual learning.
3. *The niche theme is machine learning* placed in cluster 3. This cluster involves keywords machine learning, deep learning, classification, artificial intelligence, data mining, big data and sentiment analysis etc.
4. *The emerging or declining theme is ontology* exemplified by cluster 4, containing keywords ontology, semantic

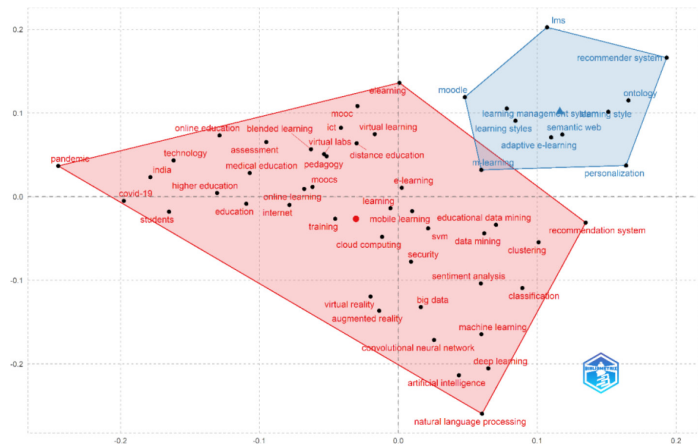


Figure 4: Factorial Analysis Map.

web, clustering, personalization, learning style, adaptive e-learning, recommendation system etc.

A knowledge map of the e-learning topic was constructed from the data of articles presented in Figure 4 to provide a relevant view of the current stage and a general description of the knowledge structure. These terms are at the centre of the conceptual structure, identified by terms such as: ‘elearning’, ‘online education’, ‘moocs’, ‘recommendation system’, ‘mobile learning’, ‘cloud computing’, ‘ict’, ‘virtual labs’, ‘machine learning’, ‘artificial intelligence’, ‘big data’, ‘augmented reality’ etc. and they are related to ‘m-learning’, ‘semantic web’, ‘adaptive learning’, ‘moodle’, ‘ontology’, and ‘learning management system’. Factor analysis is a multivariate technique that allows us to reduce the sample size without too much information loss.

Mapping of Keyword Co-occurrence

Figure 5 shows the diagram of the most frequent keywords used by authors. Therefore, out of 8038 keywords, 180 were selected to draw the visualisation graph with 1965 links and 3967 total link strength. These keywords are categorised

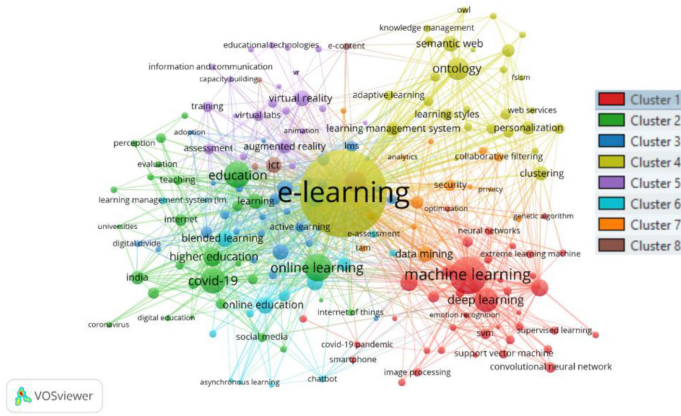


Figure 5: Co-occurrence Network Map of Author's Keywords.

and visualised in eight clusters. The first cluster in red colour comprises 39 keywords (*artificial intelligence, artificial neural networks, classification, computer vision, covid-19 pandemic, decision tree, deep learning*). The second cluster in dark green colour includes 29 keywords (*communication, coronavirus, covid-19, curriculum, data analysis, digital education, digital learning*). The third cluster in blue comprises 29 keywords (*active learning, adoption, collaborative learning, digital divide, digital literacy, distance education*). The fourth cluster in yellow colour represents 28 keywords (*adaptive learning, adaptive e-learning, clustering, e-learning, e-learning system, information retrieval*). The fifth cluster in violet colour consists of 21 keywords (*animation, assessment, augmented reality, capacity building, cognitive learning, education technology*). The sixth cluster in cyan colour consists of 15 keywords (*asynchronous learning, blended learning, chatbot, e-assessment, elearning, learning management system*). The seventh cluster in orange colour consists of 14 keywords (*analytics, big data, blockchain, cloud, collaborative filtering, data mining*). The eighth cluster in dark red colour consists of 5 keywords (*cloud computing, e-content, ICT, NPTEL, technology enhanced learning*).

Author Collaboration Map

Figure 6 shows the authorship map according to the weight of documents. Kumar A ranked top with 33 documents gaining 129 citations and ten total link strength, followed by Kumar S (NP=27; TC=143), Roy S (NP=26; TC=114), Gupta S (NP=23; TC=47) and Bijlani K (NP=22; TC=156). As well, Figure 7 represents the co-authorship by giving weight to citations. It can be seen that the author Singh R ranked first by receiving 320 citations for 21 documents, followed by Nedungadi P (TC=245; NP=16), Raman R (TC=226; NP=17), Sharma D (TC=194; NP=10) and Achuthan K (TC=175; NP=18) respectively.

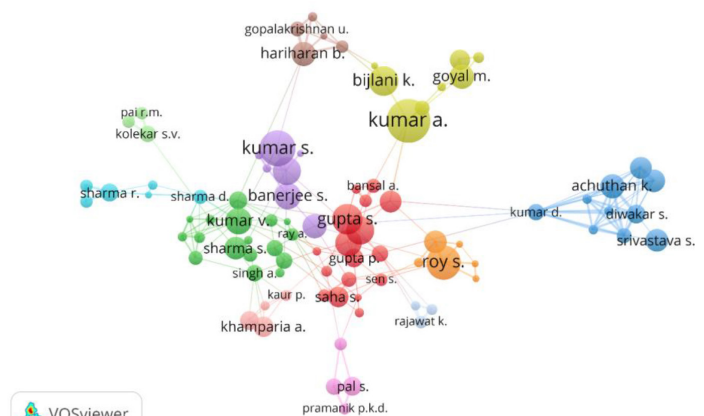


Figure 6: Author Collaboration (Publications).

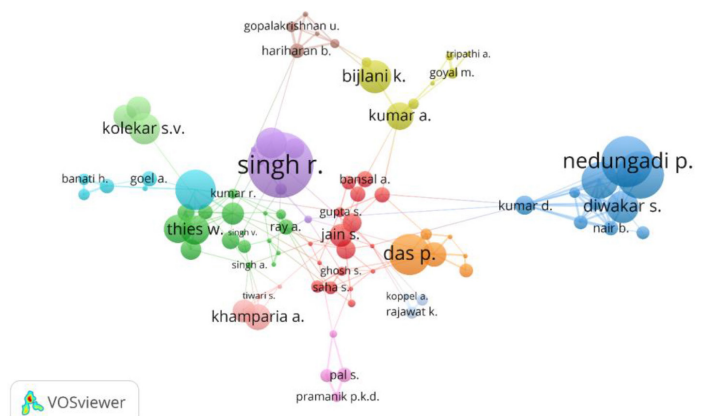


Figure 7: Author Collaboration (Citations).

CONCLUSION

The bibliometric methodology is helpful to identify trends and publication patterns in a given field of study, as in our case in *e-learning* in a given period, to limit the time and see the evolution and trend from 2010 to 2021. This study identified the most relevant sources, the most cited authors and the most recurrent words, the institutions with the most publications, and the countries. It also allows us to identify the impact quantitatively of the authors, sources, institutions, keywords and countries. The study findings observed that the two-author publication pattern was most favoured, and single-authored publications were lesser. The maximum number of publications was recorded in 2021 (734), followed by 442 publications in 2020. The study results reveal that the maximum number of papers were published as conference papers (1797), followed by journal articles (1165). Bijlani K., Achuthan K., Goyal M., and Hariharan B. were the most prolific authors. *ACM International Conference Proceeding Series, Advances in Intelligent Systems and Computing and Lecture Notes in Computer Science* were the furthestmost preferred sources during the study period. There is a need to study

the relationship between 'e-learning' and these variables in upcoming research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

NP: Total number of publications; **TC:** Total number of citations; **CPP:** Average citations per paper; **AC₅₀:** Papers having at least fifty citations or more; **SJR:** SCImago Journal Rank; **TCpY:** Total citations received per year.

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