Modeling Socio-Economic Consequences of COVID-19: An Evidence From Bibliometric Analysis

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The COVID-19 pandemic has pushed the world towards a digital era and affected the environment significantly. The present study uses a bibliometric approach to provide a comprehensive overview based on existing literature related to COVID-19 and E-learning and its environmental consequences, particularly from the year 2020–2022. In addition to the terrible impact of the pandemic on the world, environmental advantages have also been noticed. The findings show that the use of E-learning reduces the consumption of paper and prevents the cutting of trees which makes the environment more sustainable. The optimum use of technology leads to the conservation of the environment. Second, E-learning ensures developing and less developing countries to provide education at lower levels or remote areas of the society. The findings also suggest that governments and educational institutions should upgrade technology and digital tools in order to enhance E-learning education. Additionally, reviewing 1807 published articles extracted from the SCOPUS database, enrich literature related to COVID-19, E-learning, and the environment. This study also represents a graphical visualization of the bibliometric analysis using VOSviewer and R studio software. A coupling map and three-field plot also have been used for directions for future research.

Keywords: socio-economic activities, COVID-19, VOS-viewer, bibliometric, coupling map, R studio

INTRODUCTION

The COVID-19 pandemic does not only manifest multiple complexities for human lives but also severely affects the socio-economic conditions of the people. Each and every sector has been badly hit by this deadly disease, directly or indirectly, throughout the world (Razzaq et al., 2020; Wang & Tian, 2021). In addition to the negative aspects of the pandemic, some positive outcomes have also been seen in relation to the environment. Due to the lockdowns and other travel restrictions, environmental improvement was also noticed. Improved air and water quality, reduced noise pollution, and minimized energy consumption are some of the key well-beings for the environment. Additionally, a revolution has occurred in the education sector in the form of Online/E-learning. It enables teaching-learning activities more convenient. Hence, affordability, flexibility, and accessibility are considered determinants of E-learning. The main aim of this study is to extensively explore the diverse consequences of the pandemic. It also provides an insight into

the environmental knowledge that helps to formulate policies for a sustainable environment. The present study indicates that E-learning is an effective tool to reduce the excessive use of paper which prevents the cutting of tree and helps to maintain the environmental sustainability.

Particularly, the education sector has been highly affected by this pandemic across the globe. The effect of this pandemic is unprecedented and wide which has disturbed the entire community of teachers and students. As a result of this tragedy, many schools, colleges, and universities were temporarily shut down, globally (Daniel, 2020; Rashid & Yadav, 2020). However, several tactics, for instance, lockdown, social distancing, and stay-at-home were implemented by the administration of the different countries to deal with and control the spread of this transmitted disease (Sintema, 2020; Pokhrel & Chhetri, 2021; Singh et al., 2021). At the same time, educational institutions were scrambling to come up with solutions to these fierce circumstances. During such situations, Online or E-Learning proved as a panacea and facilitated teaching-learning activities (Dhawan, 2020). Online classes provide innovative teaching-learning methods, advanced tools, and techniques as well as the ability to reach a large number of students (Appana, 2008). On the other hand, students and teachers become familiar with emerging technologies, for example, how to use various tools and methodologies, pay concern to recorded or live talks with world-known professionals, interact and learn lessons often, and work with creativity pace (Arkorful & Abaidoo, 2015).

Furthermore, the pandemic has completely transformed the traditional pattern of education into digital. Before such changes, people were not much conscious of academic E-resources. It could be said that E-learning made teaching-learning more accessible, flexible and affordable (Dhawan, 2020). Teachers and students can now easily collaborate anytime and anywhere for learning activities, there is no need for physical classrooms. Especially in India, most of the students belong to rural or remote areas and it was difficult for them to get an education due to the lack of resources, online learning provides a chance to obtain substantial education (Alvi & Gupta, 2020). Apart from the several advantages of online learning, challenges and difficulties also exist. It was a great challenge for the entire educational community to transform themselves to deal with such a digital era. Therefore, the government is more concerned about education during and after COVID-19 and has taken several initiatives for dealing with the smooth teaching-learning process across the world (Singh et al., 2021). Consequently, multiple digital-educational platforms, EdTech startups, and online learning portals came into the limelight to continue the educational system's rhythm. E-learning resources made education much more convenient and facile. One can easily access academic and professional literature from anywhere within a few moments using strong internet connectivity. However, a variety of issues and topics associated with E-learning have been explored in recent years in multiple disciplines including science, social sciences, engineering and technology, and management (Djeki et al., 2022). To be familiar with emerging and trending researches, most-contributed universities and countries, and

influential articles and authors in the field of education become approachable using E-learning. For a deep and extensive understanding of this wide and diversified topic, a thematic review of related works is required. Several research articles exist related to "COVID-19 and E-Learning", but a few of them have been done with bibliometric analysis. The "COVID-19" and "E-Learning" keywords have been frequently used to search out research papers containing bibliometric analysis. A bibliometric analysis is an analysis tool to investigate the existing literature using some specific keywords and set criteria. The main objective of the present study is to examine the research trends and topics concerned with COVID-19 and E-Learning and to analyze how the educational pattern has transformed within the foregoing 3 years (i.e., 2020–2022). The bibliometric analysis method has been employed on the SCOPUS database from the year 2020–2022 to exhibit the research themes and effective entities.

Apart from the tremendous influence of COVID-19 on human lives, economy and culture, it has also proved a panacea for the environment from different perspectives (Alvarado et al., 2021; Dagar et al., 2021). In addition, online learning is an excellent source to reduce paperwork that results in saving trees, minimizing pollution and emission from traffic, less energy consumption, and water and other natural resources being conserved (Jan et al., 2021; Islam et al., 2021; Khan et al., 2022). These are the unavoidable and indirect benefits of online learning that help to create a sustainable environment (Zhang et al., 2022). Environment conservation is the major concern of the world under which several initiatives are being taken across different countries (Rehman et al., 2021; Zakari et al., 2021). The pandemic has coerced the educational system to change from traditional patterns to online learning. During the pandemic, obtaining proper education was a great challenge across the world due to the lockdowns and shutdown of schools. In this regard, E-learning proved as a catalyst to maintain the rhythm of systematic educational activities. E-learning plays a crucial role in the education sector making people aware of how to utilize the emerging resources for getting an education without exploitation of the pandemic restrictions. Hence, E-learning has been considered as an eco-friendly instrument to use in which multiple resources could be sustained for the long term (Irfan et al., 2021). Prior studies have not had many environmental concerns while this study mainly focuses on environmental sustainability through the implementation of E-learning resources. With the aim to emphasize on the socio-economic outcomes of the pandemic, the present study is distinct from previous ones. The incorporation of the bibliometric approach reveals the research novelty in examining the wide range of consequences of COVID-19. This study enhances the awareness among consumers about environmental conservation through the optimum use of digital resources and reports the wide range of socio-economic consequences globally.

Therefore, based on the aforementioned discussion, this study proposes the following objectives. First, the present study tries to investigate the socio-economic consequences of COVID-19 from different perspectives using bibliometric analysis. Second, this study reports the influences of COVID-19 regarding the environmental concerns. Third, it also extensively marks the

impacts of COVID-19 from the educational as well as socio-economic perspectives. Fourth, it also identifies the most-relevant journals, articles, institutions, and authors in this field of study, as well as the collaboration network of authors and universities. It also examines the COVID-19 and E-Learning research trends and publication productivity from 2020 to 2022. Authors and countries have made a significant contribution with respect to COVID-19 and E-Learning research; therefore, this study investigates the most-cited publications on the subject of COVID-19, E-Learning, and education research and reports on the emerging research topics and trends in the field of education.

REVIEW OF LITERATURE

In addition to the gruesome effects of the COVID-19 pandemic on human lives, it has proved a catalyst for the environmental aspect. In addition, travel restrictions lead to the minimization of air pollution, water pollution, and exploitation of natural resources (Alvarado et al., 2022; Razzaq et al., 2022). Conservation of the environment and natural resources has been a major concern of the world ever. But during/after the COVID-19 pandemic, several positive changes have been seen with respect to the environment and its sustainability (Razzaq et al., 2021). Lockdowns, social distancing, and other restrictions imposed by the government to facilitate the environmental rectification such as improved quality of air and water, CO_2 emissions reduced by transportation, Information and communication technologies, and technological innovation, and also decreased the energy consumption (Chien et al., 2021; Islam et al., 2021; Razzaq et al., 2021). During the pandemic, apart from the environmental advantages, integration of the different means of information and communication technology has taken place to deal with the pandemic hindrances and maintain the magnifier of the education sector (Irfan et al., 2022). Online learning, one of the most significant instruments of information technology, has emerged in the education sector that has made teaching-learning activities more convenient by providing E-learning assistance without violation of the pandemic norms (Chauhan et al., 2021). Certainly, E-learning is also an exquisite means of conservation of the environment by reducing the use of paper which is the main cause of cutting down the trees. Moreover, E-learning contributed a lot to the education sector during the pandemic while it was not much prevalent earlier but now has become a convenient instrument for getting an education.

Several meta-analyses and bibliometric analyses have occurred related to the education sector and COVID-19. For instance, Djeki et al. (2022) conducted a bibliometric study using 12,272 articles related to E-learning from the year 2015–2020 using the Web of Science database in which they examined the collaborations between authors, universities, and countries, and trending research topics and issues. Resulted collaborations are very low and the pandemic has a significant influence on education during the period. Baber et al. (2022) have reviewed 2307 research articles extracted from the Web of Science database related to the digital literacy pre and during the COVID-19 pandemic. Cluster analysis has been done to identify the

rotative keywords and their thematic progression and trends over 5 years. In conclusion, a consistent pace of publications comes from the domains of education and library, and the United States moving ahead in this area. Moreover, some trends are emerging such as competence, health literacy, fake news, COVID-19, and education. Chaturvedi et al. (2021) have explored the impact of COVID-19 on the education, mental health, and social life of students belonging to different age bars through a set criterion. The results have shown that the administration should pay deep concern and adopt essential steps for improving the learning experience and cope with the negative impact of the pandemic. A systematic review has been conducted by Donnelly and Patrinos (2021) that reported the learning loss due to COVID-19 for 1 year. On the basis of eight studies, the author reported that one of them claimed learning gains in a specific subgroup and the rest have witnessed heavy learning loss. Some of the studies reveal inequality among demographics of students resulted in a learning loss. According to Abu Talib et al. (2021), technological advancements rapidly took place in the field of higher education during the period of a pandemic. To deal with unprecedented changes in the education field, the educational system has now become more dependent on technology. In the light of emerging trends in technology-based education, it would not be wrong to say that gaining education without using technology would be impossible in the near future. A bibliometric analysis was performed by Karakose and Demirkol (2021) to examine the emerging trends and current status associated with COVID-19 and the education, in which data has been extracted from the "Web of Science Core Collection" and analyzed using VOSviewer and "GraphPad" software. They found that most of the articles were published with a "theoretical model" using "scale/interview forms". Another interesting finding is that articles sent for publication at that time were responded to very quickly and got published before the usual time period of respective journals. Adedoyin and Soykan (2020) reported the opportunities and challenges regarding COVID-19 and online learning in a previous study; E-Learning would be more effective and sustainable if the teaching-learning would become hybrid. Accordingly, the distinctiveness of the current study is to explore the literature of highly sensitive years (2020, 2021, and 2022) of the COVID-19 pandemic which has enormous unprecedented transformations in different facets of normal life and simultaneously educational perspectives. Most of the studies have been conducted using the Web of Science database but this study is being conducted with the Scopus which is the largest combination of abstract and citation database of reputed peer-review literature. It widely covers approximately 36,377 titles, around 11,678 publishers, and around 34,346 peer-reviewed journals on multidisciplinary subjects. No previous studies have revealed the influence of information technology means, that is, online/E-learning on environmental and socio-economic perspectives through the existing literature during/post-pandemic. The present study bridges this gap by bringing a more lucid and vivid study on e-learning and the environment.

An overview of studies related to COVID-19, e-learning, and environment.

An overview of studies related to covid-19, e-learning and environment

References	Period	Data source	Methodology	Outcomes
Djeki et al. (2022)	2015–2020	Web of Science Core Collection	Bibliometric Analysis	COVID-19 has a significant impact on e-learning
Baber et al. (2022)	2017–2021	Web of Science Core Collection	Bibliometric Analysis	COVID-19 has been associated with fake news, higher education, social media, and information literacy
Karakose & Demirkol (2021)	2020–2021	Web of Science Core Collection	Bibliometric Analysis	COVID-19 has affected education negatively
Abu Talib et al. (2021)	2019–2020	Google Scholar	Systematic Literature Review	Lockdown has negatively impacted education and promotes online learning
Chaturvedi et al. (2021)	13 July–17 July 2020	cross-sectional survey (Primary Data)	Non-parametric test and Chi Square test	COVID-19 outbreak has made a significant impact on the mental health, education, and daily routine of students
Donnelly & Patrinos (2021)	2020–2021	ECONLIT, Google Scholar, PubMed, Education Resources Information Center, and Cochrane Library	Systematic Literature Review	Student learning loss among participants while one of these found instances of learning gains in a particular subgroup. Some studies observed increases in inequality where certain demographics of students experienced learning losses more significant than others
Islam et al. (2021)	1972–2016	World Development Indicator (WDI)	dynamic ARDL	The environment has been affected positively by Transportation, quality of air, and the manufacturing sector during COVID-19

DATA COLLECTION AND RESEARCH METHODOLOGY

Data Collection

The Scopus database was used to collect extensive professional and scientific literature to cover global research on E-learning and COVID-19. The data was extracted on 18 March 2022. The key terms have been used in the search: topic = ("E-Learning" and "COVID-19"), in title-abs-key ("e-learning" and "COVID-19″) and [limit-to (doctype,"ar")] and [limit-to (srctype,"j")] from 2020 to 2022, and 4207 studies were found over the years (Conference paper 1882, Articles 1807, Review 169, Letter 140, Editorial 62, Conference Review 47, Book Chapter 36, Data Paper 6, and Short Survey 5) but the researchers have selected only research articles in this study.

The data of the bibliometric study represent the entire research on "COVID-19 and E-learning" in the Scopus database. The usage of e-learning was anticipated to rise in the last 3 years (2020, 2021, and 2022) owing to the lockdown and quarantine processes.

There are various reasons why this database was chosen above others, notably web of science (WoS) and Science Direct: the area of scientometrics has improved greatly as a result of the Scopus database. Scopus is much more than a simple database of academic publications.

Research Methodology

Bibliometrics is a subfield of library science which analyzes bibliographic data statistically (Mas-Tur et al., 2020). Bibliometrics analysis is a method of gaining a comprehensive picture of huge breakthroughs in either a research journal, specific area, or a country (Hood and Wilson, 2001). Moreover, it facilitates the identification of prominent authors working in the area in order to enable future collaborations. The data were evaluated using a graphical analysis using VOS-viewer to better comprehend the results (Van Eck & Waltman, 2010). Statistical analysis and graphical representation are useful because they can assist researchers in a deeper understanding of what has been studied so far in the field of e-learning and COVID-19 related topics. Moreover, it assists in identifying and mapping the megatrends throughout this discipline. VOS-viewer is a software that gathers bibliographic data from several databases such as Scopus, PubMed, Science Direct, and Web of Science, etc. It provides graphical maps that depict and present the results of several procedures, such as co-citation analytics, bibliographic coupling, co-authorship, and keyword co-occurrence (Guo et al., 2021). When two articles are cited by the same third article, this is known as co-citation. The tremendously valuable results of bibliographic coupling have been evaluated by determining those common articles that cite the articles in observation more frequently. Co-authorship refers to the number of publications produced by a group of variables, such as countries, authors, and institutions, as well as their relationships. The most frequent and common keywords used by the articles in the study are referred to as co-occurrence of keywords.

Lotka's Law is considered a bibliometric measurement of authorship concentration that quantifies the frequency with which authors publish research articles. The key premise is that in any particular topic, a limited number of authors are extremely productive, while a large number of authors contribute only a single article. According to Lotka's law, the numerous authors who publish x number of articles is about $1/x^b$ of those who only publish one article. As a result, a larger b value implies greater authorship concentration, while a low value implies the absence of a devoted group of authors in a certain research field. Lotka's Law does have the following general formula:
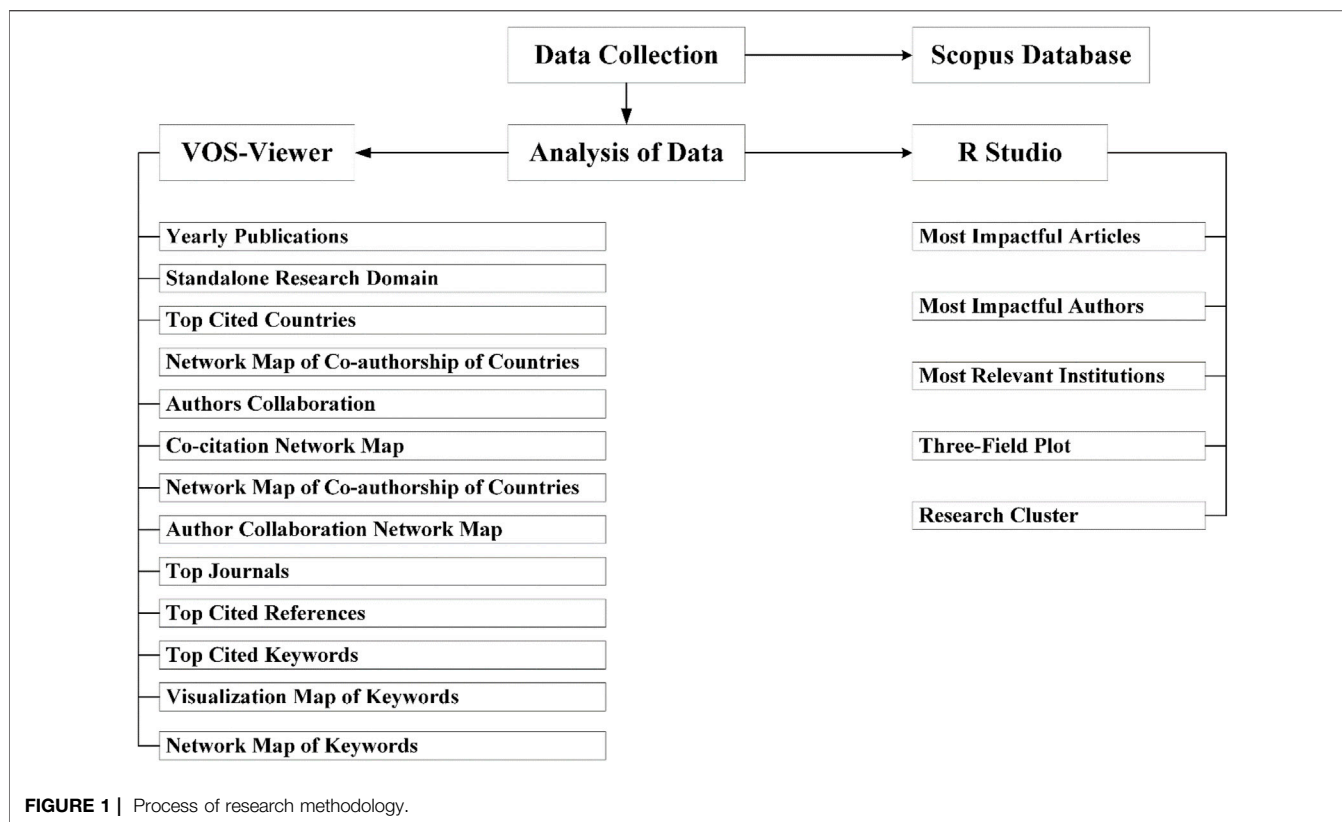
$$f(y) = \frac{C}{x^b} \tag{1}$$

FIGURE 1 | Process of research methodology.

C is a research area-specific constant, while f(y) is the number of occurrences of studies produced by each author of a population.

Using a Walktrap clustering technique provided by Pons and Latapy (2005), we show university and author collaboration. This network analysis approach has a notable advantage in terms of the quality of the calculated partition and the running duration for large networks (Pons & Latapy, 2005). Additionally, we employ a *Three-Fields* plot based on a Sankey diagram to depict the relationships between journals, keywords, and countries. Kessler's (1958) bibliographic coupling approach is utilized to identify the cluster of the underlying research and map present research advances. Two or more publications are said to be bibliographically coupled if they carry at least one common citation (Kessler, 1963). As a result, studies that are bibliographically coupled are likely to share the same underlying research theme. The following standard formula can be used to express a bibliographic coupling network of studies published (Aria & Cuccurullo, 2017).

$$B_{coup} = A \times A \qquad (2)$$

B_{coup} consists of the matrix b_{ij}, which reflects the number of common references between articles, and A is a document × cited reference matrix. We have used the open-source R programming application Bibliometric package (Biblioshiny) to analyze bibliographic coupling (Aria & Cuccurullo, 2017). **Figure 1**.

TABLE 1 | Total publications over the years.

Publication years	TP	% of 1807
2020	340	18.81
2021	1184	65.52
2022	283	15.66

Note: TP, total publications; % of 1807, Percentage over the years.

RESULTS AND DISCUSSION

Yearly Publication Trends

The yearly publishing trend is useful for determining the topic's progress, literature accumulation, and maturity. **Table 1** shows that there were 1807 articles published between 2020 and 2022. The highest research articles were published in 2021 (65.5%). It was more than 50% over the years like 2020 (18.8%) and 2022 (15.6%). The trend of publication is an inverted V shape because in 2021 more than 50% published articles. And the year 2022 has also seen a good number of publications until the 18 March of 2022.

Standalone Research Domain

Research productivity in the context of e-learning and COVID-19 in education demonstrates that there are 6977 authors in this field who have published only one publication. One author, on the other hand, has contributed to a maximum of seven published research articles. According to Pao (1986), the value of b in Lotka's law normally ranges from 1.78 to 3.78 for most fields. In

TABLE 2 | Top 10 most impactful authors in this field.

Rank	Author	TP	TC	TC/TP	TLS
1	Stuby L.	6	59	9.8	27
2	Suppan L.	6	59	9.8	27
3	Suppan M.	6	59	9.8	27
4	Harbarth S.	5	53	10.6	25
5	Sharma S.	5	195	39.0	0
6	Gartner B.	4	53	13.3	22
7	Purwanto A.	4	58	14.5	0
8	Raza S.A.	4	52	13.0	6
9	Wang W.	4	57	14.3	2
10	Wu H.	4	60	15.0	2

Note: TP, total publications; TC, total citation; TC/TP, average citations of per paper; TLS, total link strength.

TABLE 3 | Top 10 most cited Countries.

Country	TP	% of 1807	TC	TLS
United States	245	13.558	1336	133
Saudi Arabia	146	8.080	1084	264
United Kingdom	96	5.313	817	80
China	118	6.530	783	111
India	151	8.356	743	130
Pakistan	56	3.099	630	111
Spain	99	5.479	602	109
Malaysia	83	4.593	572	155
Italy	77	4.261	529	78
Indonesia	95	5.257	522	122

Note: TP, total publication; TC, total citation; TLS, total link strength.
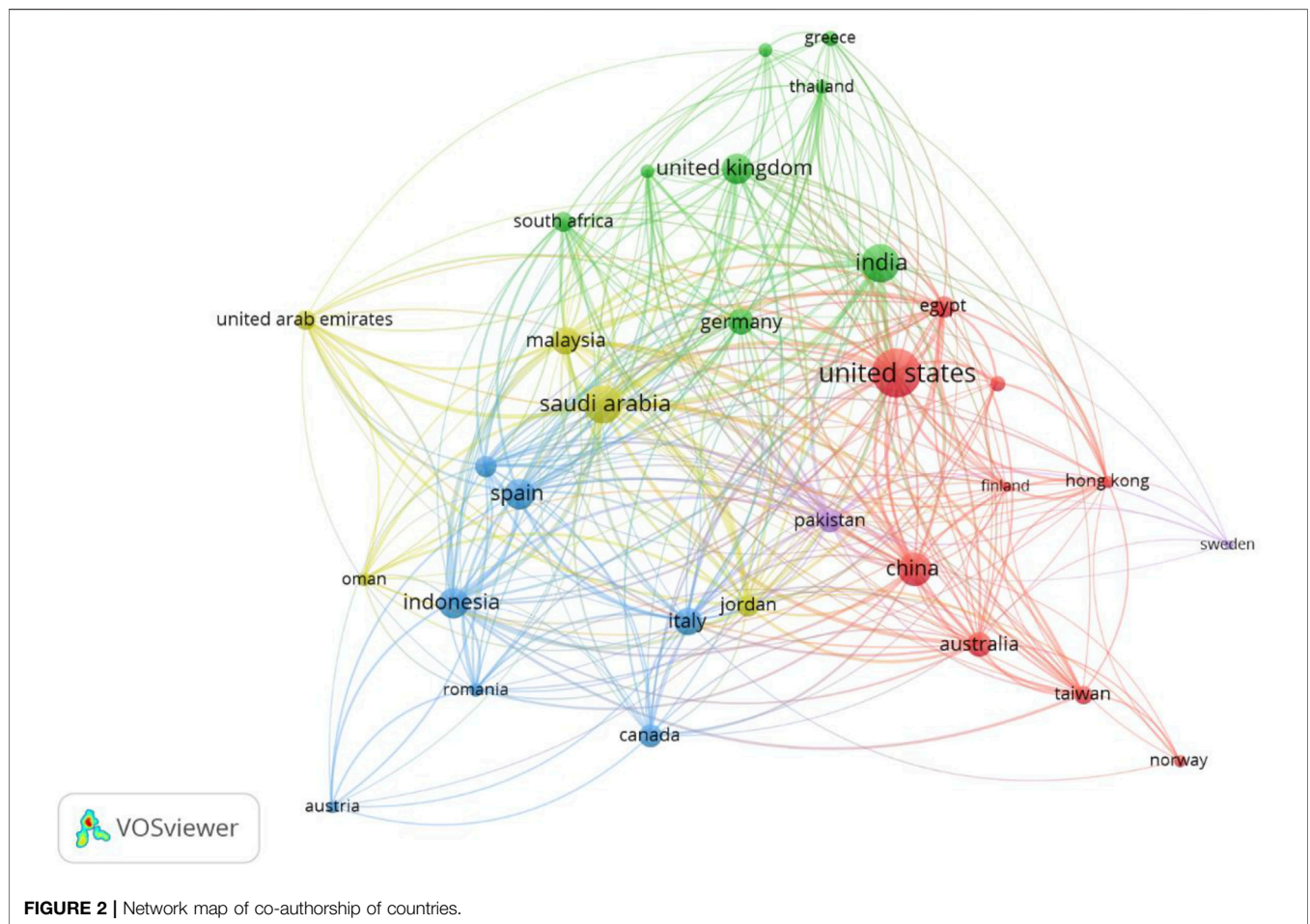

FIGURE 2 | Network map of co-authorship of countries.

this investigation, the calculated b value of 1.904 fits within the range seen by (Pao, 1986). As a result, e-learning and COVID-19 in education constitute a separate research topic, although one with a high degree of authorship concentration.

Analysis of the Top 10 Most Cited Countries

The geographic distribution of articles may be discovered by looking at the number of countries that were published in this field. According to

Table 2, the United States has published the most prominent productive research articles on the field of e-learning and COVID-19 from 2020 to 2022, and United States has published 245 articles (13.5%), preceded by India, which published 151 articles (8.3%). The top 10 countries published 1166 out of 1807 articles, which contributed to 64.52% of the total on the topic of e-learning and COVID-19 and the rest of the country's 35.48%. **Figure 2** shows that the United States and India have published the most publications on

FIGURE 3 | Network map of author collaboration.
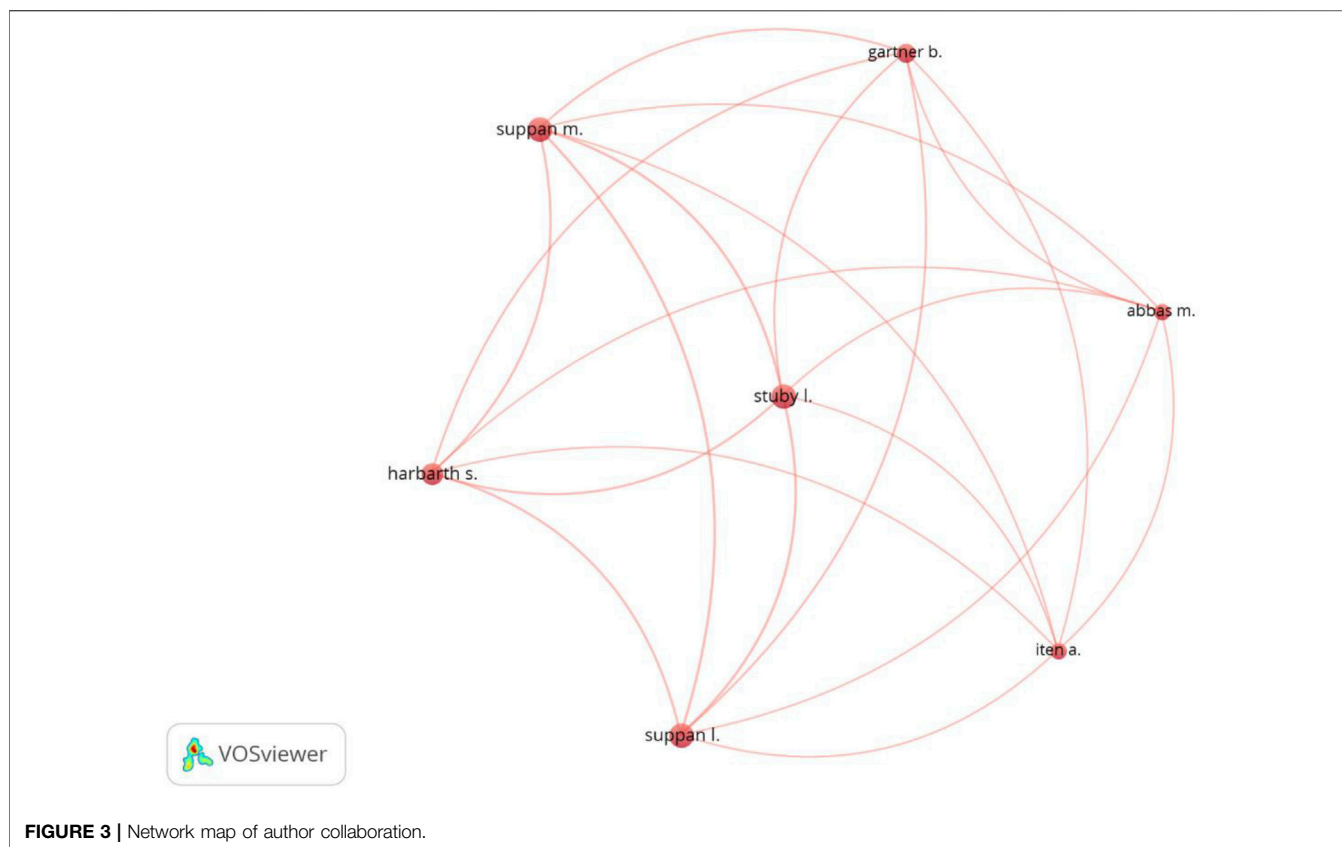
this topic. The most cited countries are the United States and Saudi Arabia (1336 and 1084, respectively), but India is not the most cited country as seen in the network map and **Table 3**. Saudi Arabia and Malaysia are the most collaborated countries, with 264 and 155 total link strength (TLS). United States, United Kingdom, China, India, Pakistan, Spain, Italy, and Indonesia are the countries having the most collaborations with Saudi Arabia and Malaysia. Furthermore, these two countries have collaborated with each other. The United Kingdom is the third country in terms of citations, with 817 citations, and has collaborated with the United States and Saudi Arabia. Since 2020, the United States and India have been actively publishing research articles on this field, but some countries have joined lately, such as Ukraine, Nepal, Vietnam, Croatia, Ghana, Philippines, Chile, Colombia, Finland, Morocco, Palestine, and Sweden. It's important to note here that countries that fail to collaborate with other countries are eliminated from the network map by default. The lines linking the map's nodes denote co-authorship between countries, and the length between them denotes their strength and the number of publications among co-authoring countries. This presents a comprehensive assessment of the different countries' collaboration strengths in the area of e-learning and COVID-19.

Analysis of Author Collaboration and Author Co-Citation Network Map

The examination of author collaboration indicates the topic's research potential and provides insight into the topic's advancement (Guo et al.,

2021). While analyzing the 1807 publications, the authors discovered that 7128 different authors made significant contributions in this field. The smallest number of publications and citations contributed by an author was set at 3 and 50, respectively. Nineteen authors met the criteria shown in **Figure 3** and collaborated with others. **Table 3** shows the top ten most productive contributors from 2020 to 2022. Stuby L. (6 articles, 6 links, and 27 link strength) lead the list of publications in this field. Suppan L. (6), Suppan M. (6), Harbarth S. 5), and Gartner B. 4) articles are among the other authors with a significant publication record.

Analysis of Top Journals

It is crucial to investigate the number of publications and the frequency of citations in order to identify journals in this field. **Table 4** shows the top 5 most productive journals in terms of total publication and average citation per article. International Journal of Environmental Research and Public Health has 71 articles on this subject from 2020 to 2022. This journal publishes mainly on Environmental Health, Health Economics, Digital Health, Mental Health, and Digital Learning themes and has an H-index of 113 and an impact factor of 3.39. It means that researchers frequently link digital learning to mental health and Digital health during COVID-19. It's interesting to note that the Pakistan Journal of Medical Sciences with an average citation per article (45.88) belongs to medical science and public health, indicating the importance of health during COVID-19 for humanity. Frontiers in Pediatrics has a high H-index (53) and impact factor (3.41), which is followed by the

TABLE 4 | Top 5 productive journals (total publication and average citation per paper).

Top 5 Journals in terms of total publication

Rank	Journals (TP)	Research Field,	TP	TC	TC/TP	H-Index	IF
1	International Journal of Environmental Research and Public Health	Environmental Health, Health Economics, Digital Health, Mental Health, Digital Learning etc.	71	715	1.8	113	3.39
2	Sustainability (Switzerland)	Social Sciences, Natural Sciences	43	261	11.9	103	3.25
3	International Journal of Emerging Technologies in Learning	Online Learning Tools, Blended Learning, Mash-up Technologies, Language/Speech etc.	41	117	6.4	35	NA
4	PLOS ONE	Science, Engineering, Medicine, Social Sciences	29	248	7.4	185	NA
5	Education Sciences	Education & Educational Research	27	225	8.33	39	2.15

Top 5 Journals in terms of average citation per paper

Rank	Journals (ACPP)	Research Field,	TP	TC	TC/TP	H-Index	IF
1	Pakistan Journal of Medical Sciences	Medical Sciences	8	367	45.88	35	NA
2	Journal of Surgical Education	Surgical Education,	5	94	18.80	39	2.89
3	Frontiers in Pediatrics	Science	6	95	15.83	53	3.41
4	Systematic Reviews in Pharmacy	Pharmaceutics, Biopharmaceutics, Biomedical Sciences, Law and Education etc.,	5	71	14.20	21	NA
5	Education and Information Technologies	Education & Educational Research	20	251	12.55	52	2.95

Note: TP, total publications; TC, total citation; TC/TP, average citations of per paper; ACPP, average citation per paper; IF, impact factor; Sources of H-Index and IF, journals website and google scholar metrics.

Journal of Surgical Education (H-index 39 and impact factor 2.89), indicating the importance and relevance of this field. **Figure 4** also shows the top productive journals of COVID-19 and E-learning.

Analysis of Top Cited References

The top 5 highly cited references from 2020 to 2022 were examined, as shown in **Table 5**. The highly cited article was published by the Journal of Educational Technology Systems, and it has been cited 25 times during this period. Journal of Educational Technology Systems has published articles on Information Literacy and online learning for a long time. It has gained a lot of popularity among the scholars of online learning; that is why this article is listed in the highly cited reference during this period. The third most citations were obtained in the publication Human Behavior and Emerging Technologies' article "COVID-19 and Online Teaching in Higher Education: A Case Study of Peking University". The objective of this research was to conduct a case study of online education at Peking University. Six alternative instructional approaches are presented to describe current online teaching experiences for university professors who may perform online education in similar conditions.

ATTRACTIVE RESEARCH FIELD

The frequency of occurrences of a keyword indicates the domain space and vital content of a certain topic/subject. **Figure 5** depicts the

keyword co-occurrence networks and highlights digital literacy research encompasses a varied and mixed set of areas. This map was generated using the criteria-type of analysis described as follows: co-occurrence, all keyword and counting method, and full counting. The threshold number of occurrences for a keyword in the article was set at 100 to ensure that we focus exclusively on the most prominent keywords. 32 keywords were extracted from 8263 total keywords, and the frequency and strength of the link of the top 20 keywords are demonstrated in **Table 6**. With a frequency of 1368, E-Learning is the most studied topic in this area, followed by COVID-19 (1037), Human (694), and Pandemic (582), as illustrated in **Figure 6** using density visualization. It's important to note that the most commonly occurring keyword is E-Learning and COVID-19. Although COVID-19 has recently received significant attention by people due to the pandemic issues in many areas (e.g., education, economics, and social issues), the field of pandemics considers COVID-19 as a focal keyword. Additionally, the distance between e-learning and COVID-19 is relatively near among the top five keywords, showing the keywords' strong relationship. The map classified the keywords into six distinct clusters.

MOST IMPACTFUL ARTICLES

Bibliometric techniques for TC identify seminal or recent breakthrough studies. **Table 7** shows the most cited articles in
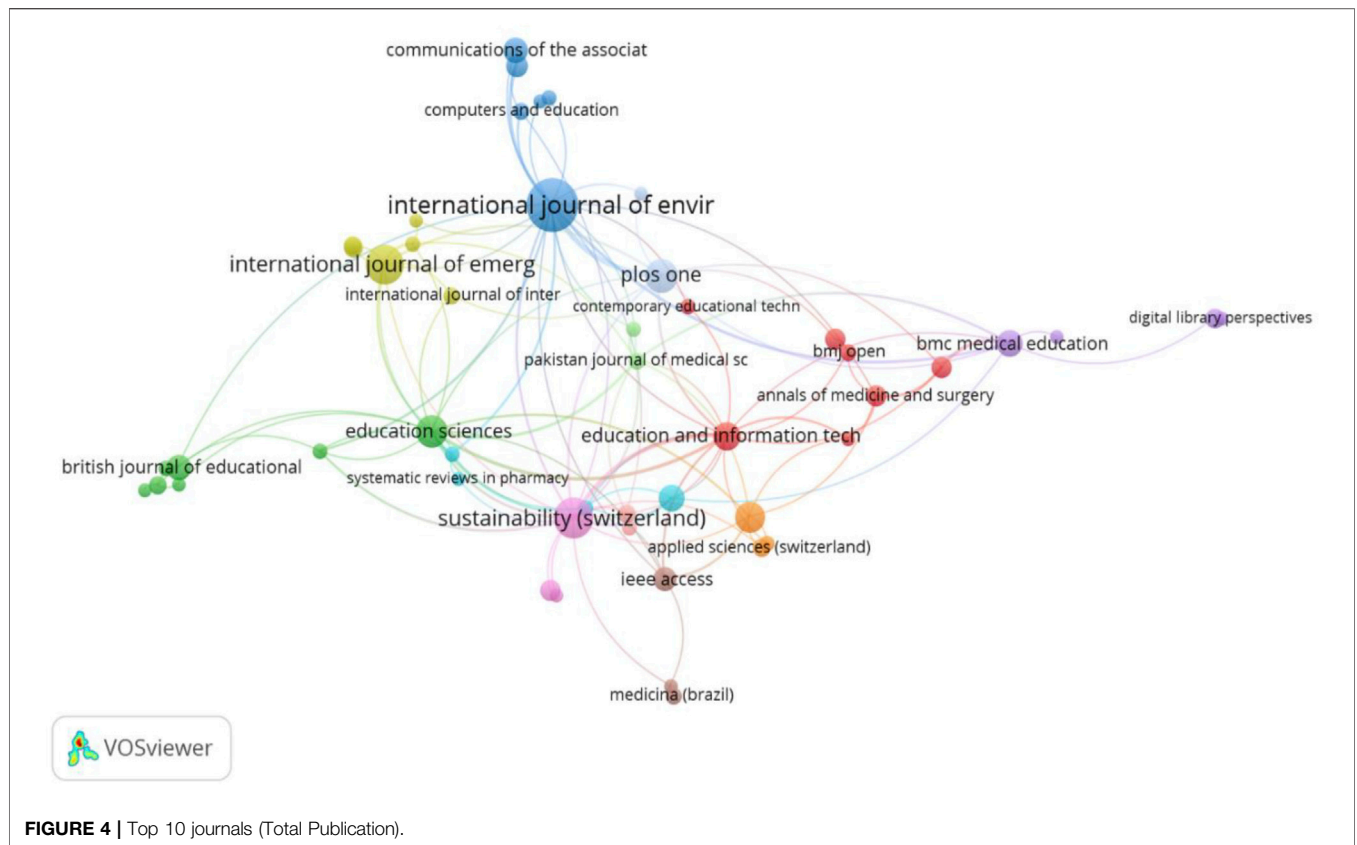
FIGURE 4 | Top 10 journals (Total Publication).

TABLE 5 | Top 5 cited references in E-learning and COVID-19.

Rank	Title	Author	Source	Year	TC
1	Online Learning: A Panacea in The Time of COVID-19 Crisis	Dhawan, S	Journal of Educational Technology Systems	2020	25
2	Evaluating Structural Equation Models with Unobservable Variables and Measurement Error	Fornell, C., Larcker, D.F.	Journal of Marketing Research	1981	18
3	Covid-19 and Online Teaching in Higher Education: A Case Study of Peking University	Bao, W	Human Behavior and Emerging Technologies	2020	16
4	Using Thematic Analysis in Psychology	Braun, V., Clarke, V	Qualitative Research in Psychology	2006	14
5	Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology	Davis, F.D.	MIS Quarterly	1989	13

Note: TC: total citation.

terms of TC. We can identify significant publications that got the most citations within and beyond the sample of 1807 studies. According to estimates, Blake et al. (2020) is the most influential article on the e-learning and COVID-19 in the education sector, with the TC 205 and TC per year 68.3. Other influential studies with TC of one include (Kapasia et al., 2020), (Mukhtar et al., 2020), and (Almaiah et al., 2020).

MOST RELEVANT INSTITUTIONS

Figure 7 represents the most-relevant academic institutions that published e-learning and COVID-19 research in this field. The

first position is King Abdulaziz University from Saudi Arabia, which contributes to 43 articles, the second is Monash University from Australia, which contributes for 41 articles, and the third position is All India Institute of Medical Sciences from India, which contributes 39 articles.

The other top relevant institutions comprise universities from Saudi Arabia (IMAM Abdulrahman Bin Faisal University, King Saud University, King Khalid University, Umm Al-Qura University, and Qassim University), Jordan (Jordan University of Science and Technology), United State (the University of California and Harvard Medical School), Indonesia (Universitas Indonesia) and Malaysia (University of Malaya). Under the top 10 universities are seven universities from Saudi Arabia.
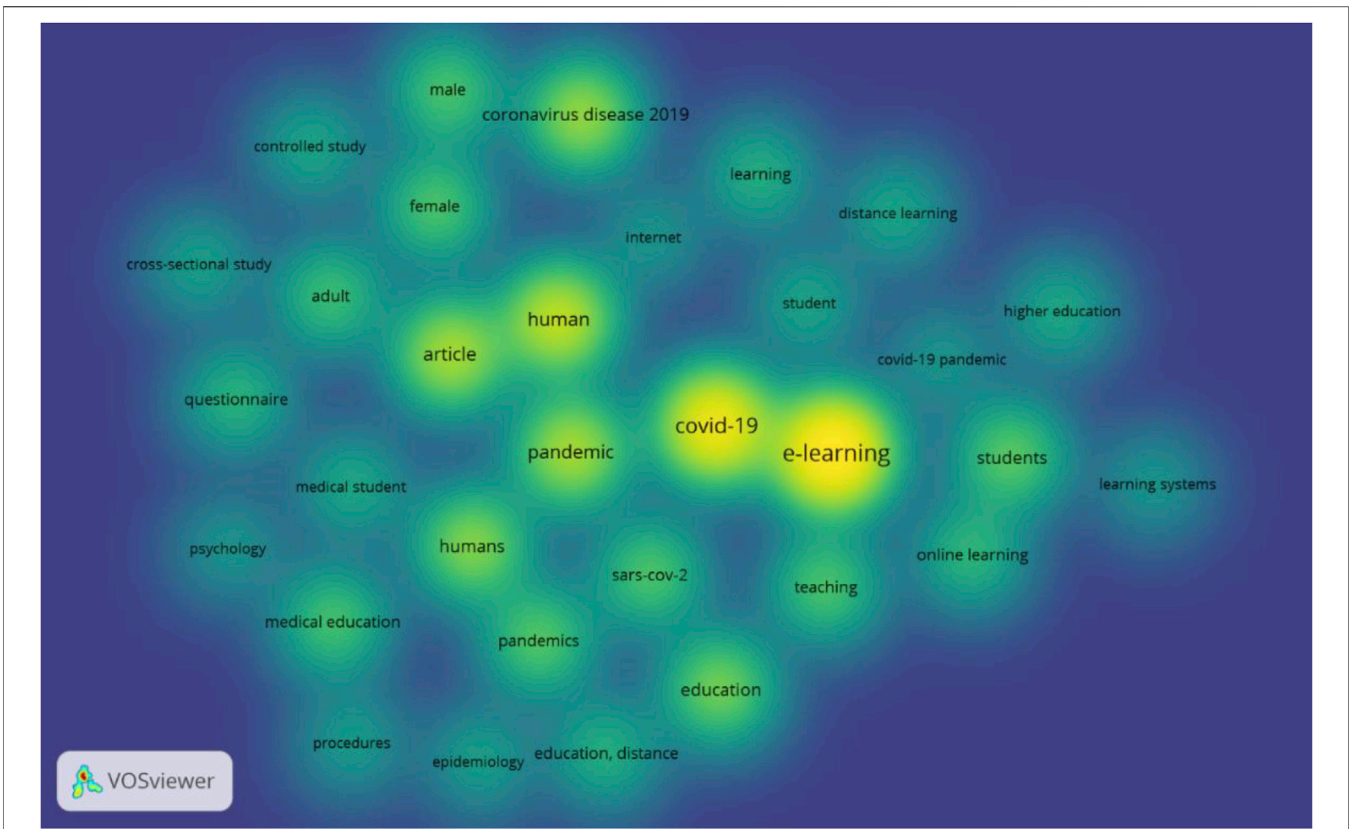
FIGURE 5 | Visualization map of keywords co-occurrence in the field of e-learning and COVID-19.

TABLE 6 | Top 20 cited keywords.

Rank	Keyword	Occurrences	TLS
1	E-Learning	1368	7982
2	Covid-19	1037	7099
3	Human	694	7300
4	Pandemic	582	6010
5	Article	580	6245
6	Coronavirus Disease 2019	512	5672
7	Humans	461	5468
8	Education	407	4279
9	Students	342	1938
10	Pandemics	325	3959
11	Sars-Cov-2	305	3568
12	Female	304	3906
13	Teaching	300	2651
14	Male	299	3870
15	Medical Education	286	3118
16	Adult	262	3400
17	Online Learning	226	1105
18	Questionnaire	212	2575
19	Education, Distance	194	2644
20	Learning	191	1828

Note: TLS, total link strength.

THREE FIELDS PLOT

Relationships among journals, research areas, and countries can share important information. As a result, in **Figure 8**, the authors provide a new Three-Fields Plot that depicts the relationships between the most-relevant publications sources (left), author keywords (middle), and countries (right) in e-learning and COVID-19 in education research. The authors observed that most research on online learning and e-learning is published in the International Journal of Advanced Computer Science and Application, with the majority of them authored by the United States and India. Generally, the United States focused on COVID-19 research, India, Saudi Arabia, and Indonesia focused on e-learning research, and all other fields were covered by almost all these countries.

RESEARCH CLUSTERS AND FUTURE RESEARCH DIRECTIONS

There are various underlying research themes in every research field. Using bibliographic coupling analysis in e-learning and
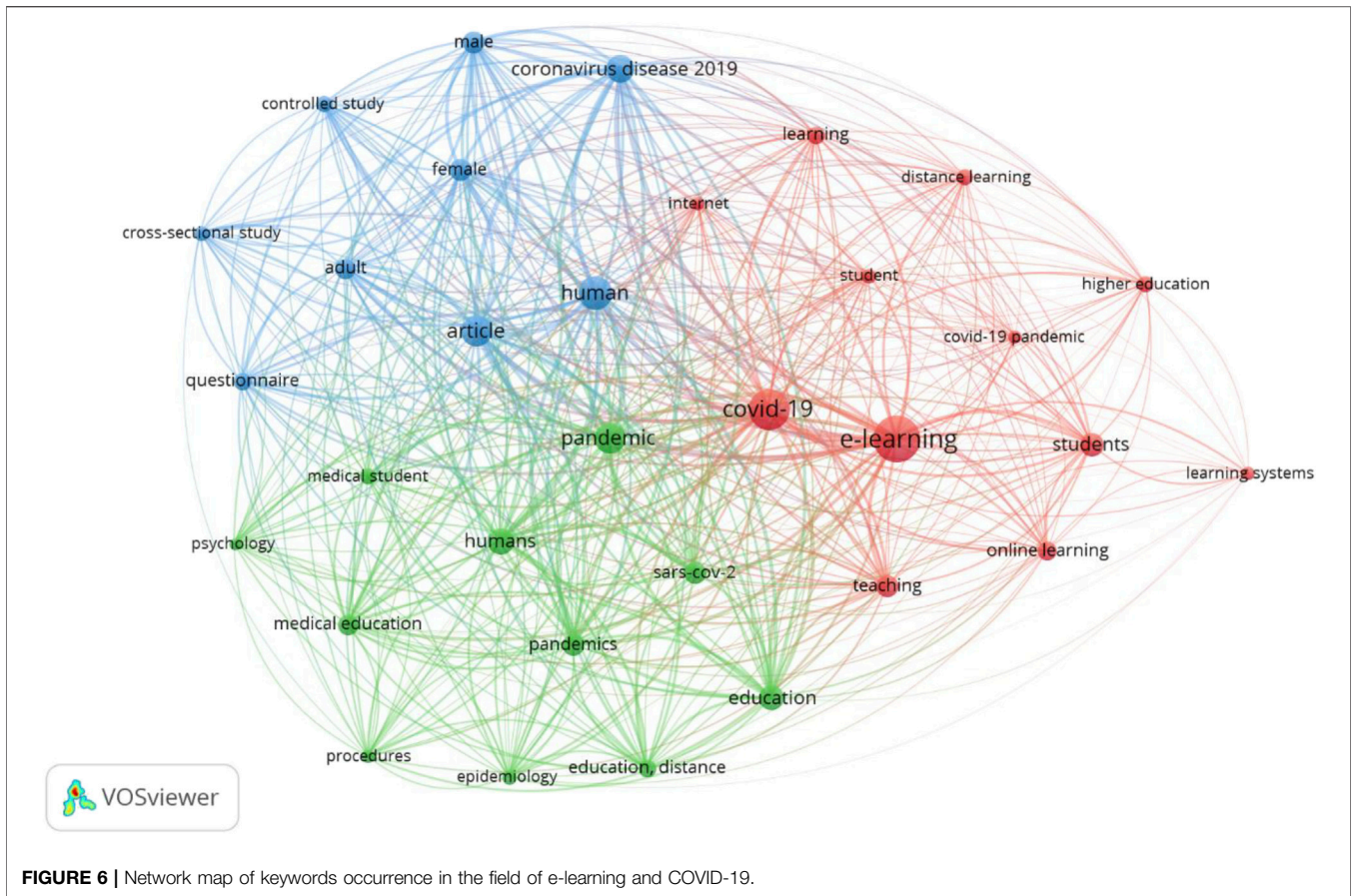
FIGURE 6 | Network map of keywords occurrence in the field of e-learning and COVID-19.

TABLE 7 | Most impactful articles.

Rank	Paper	DOI	TC	TC/Y	NTC
1	BLAKE H, 2020, INT J ENVIRON RES PUBLIC HEALTH	10.3390/ijerph17092997	205	68.3	12.3
2	KAPASIA N, 2020, CHILD YOUTH SERV REV	10.1016/j.childyouth.2020.105194	179	59.7	10.8
3	MUKHTAR K, 2020, PAK J MED SCI	10.12669/pjms.36. COVID19-S4.2785	179	59.7	10.8
4	ALMAIAH MA, 2020, EDUC INF TECHNOL	10.1007/s10639-020-10219-years	176	58.7	10.6
5	IIVARI N, 2020, INT J INF MANAGE	10.1016/j.ijinfomgt.2020.102183	169	56.3	10.2
6	FAVALE T, 2020, COMPUT NETWORKS	10.1016/j.comnet.2020.107290	154	51.3	9.3
7	SUNDARASEN S, 2020, INT J ENVIRON RES PUBLIC HEALTH	10.3390/ijerph17176206	140	46.7	8.4
8	MAILIZAR, 2020, EURASIA J MATH SCI TECHNOL EDUC	10.29333/EJMSTE/8240	138	46.0	8.3
9	HASAN N, 2020, CHILD YOUTH SERV REV	10.1016/j.childyouth.2020.105355	133	44.3	8.0
10	ABBASI S, 2020, PAK J MED SCI	10.12669/pjms.36. COVID19-S4.2766	126	42.0	7.6

Note: TC, total citation; NTC, normalized total citation; TC/Y, total citation per year.
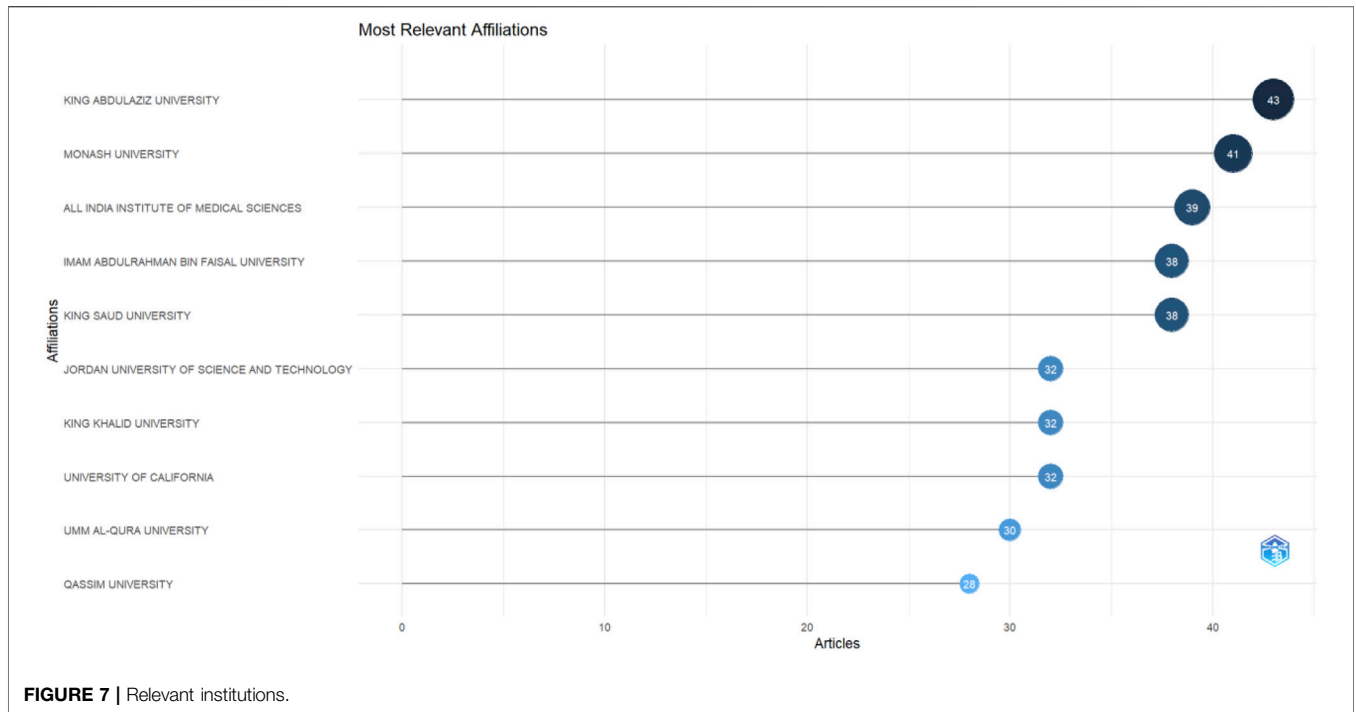
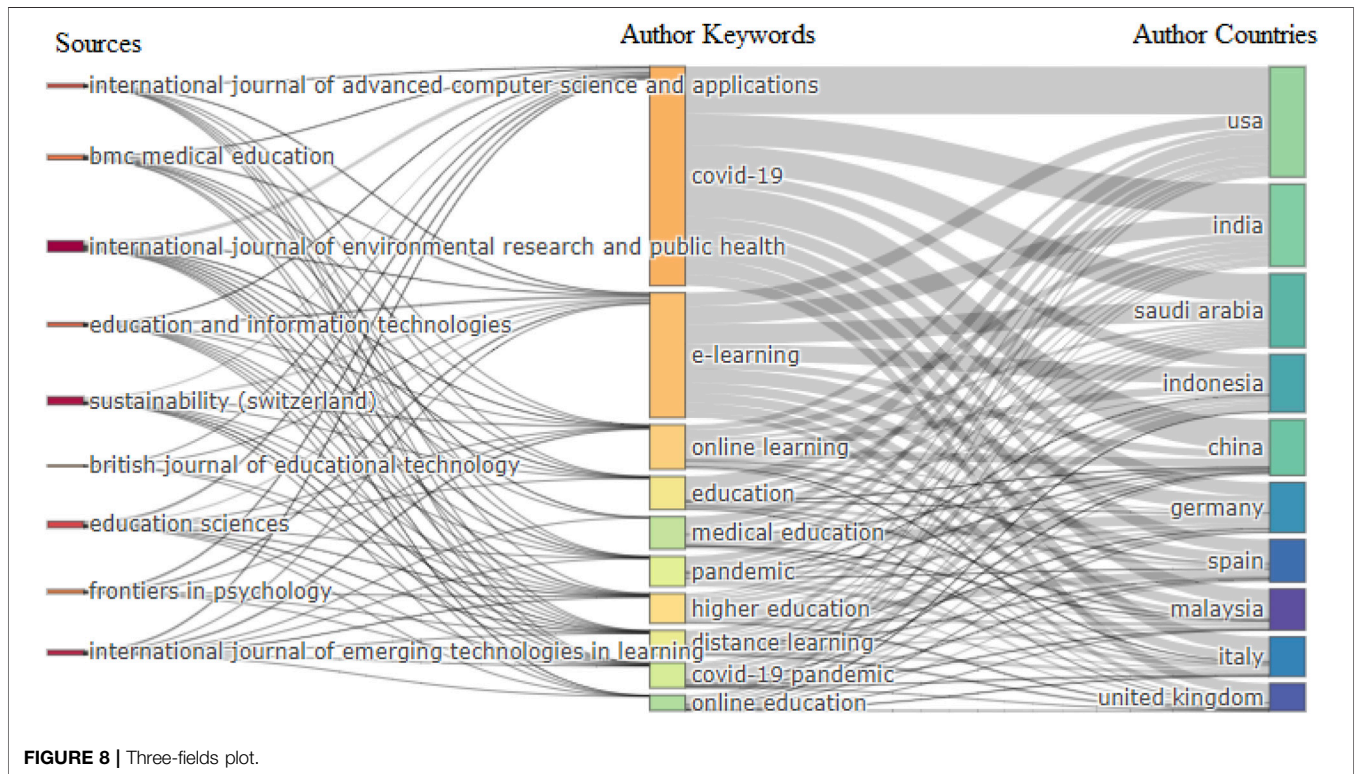**FIGURE 7 |** Relevant institutions.

FIGURE 8 | Three-fields plot.

COVID-19 in education research, the authors identified two underlying clusters: 1) COVID-19, E-learning and Online Learning, and 2) Personal Protective Equipment, Randomized Controlled Trial and COVID-19 (see **Figure 9**). Both clusters are interconnected and built on each other. Inside every cluster, the authors critically assessed the contents of bibliographically related articles that provide similar underlying study topics and extracted significant directions for future research. To conduct the content
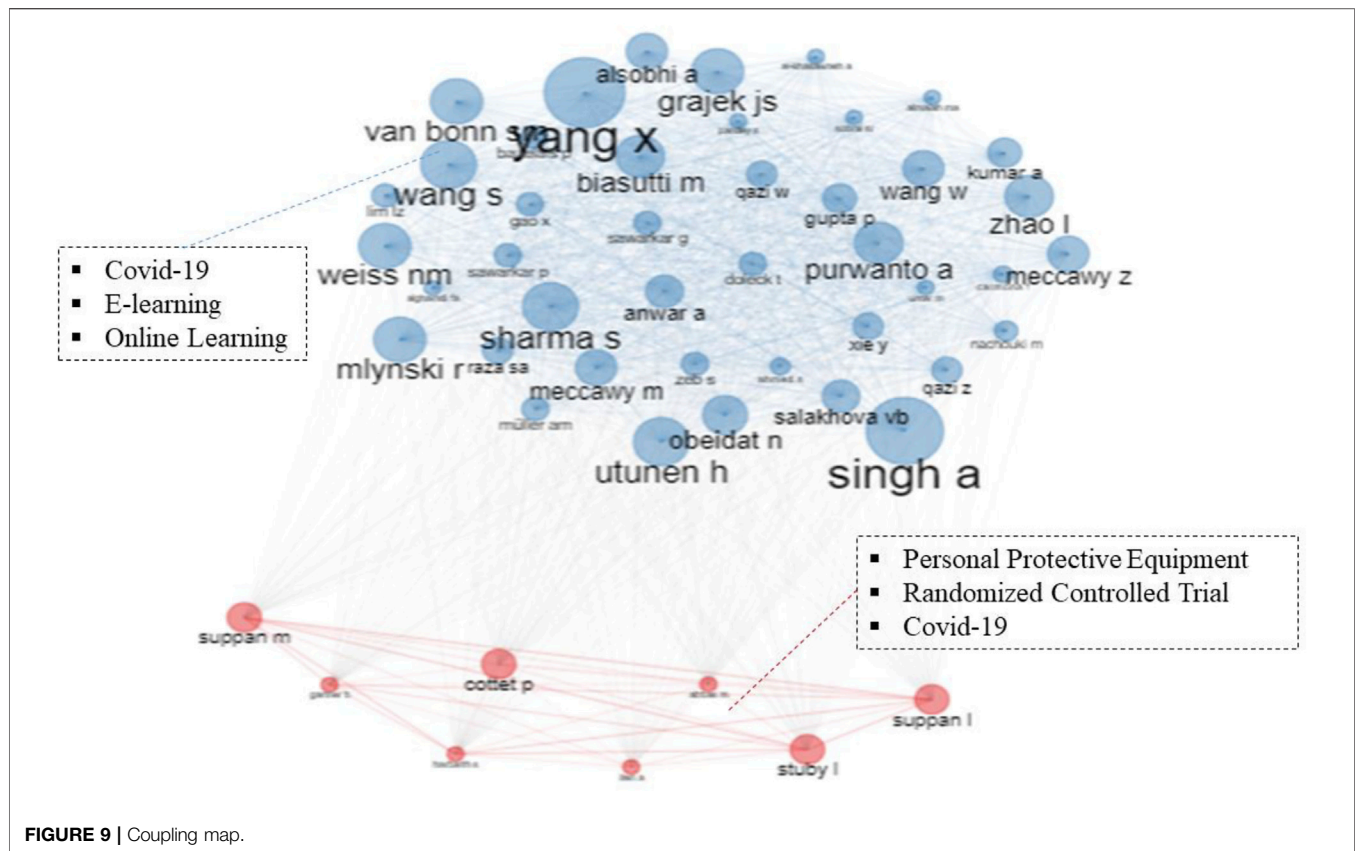
FIGURE 9 | Coupling map.

TABLE 8 | Top 10 used keyword occurrences in different years.

Rank	Keyword occurrences in 2020		Keyword occurrences in 2021		Keyword occurrences in 2022	
	Keyword	O	Keyword	O	Keyword	O
1	E-Learning	258	E-Learning	927	E-Learning	181
2	Human	179	Covid-19	735	Covid-19	128
3	Covid-19	173	Human	450	Students	69
4	Article	153	Article	376	Human	65
5	Pandemic	153	Pandemic	375	Pandemic	54
6	Coronavirus Disease 2019	151	Coronavirus Disease 2019	320	Article	51
7	Education	109	Humans	303	Humans	51
8	Humans	107	Education	254	Sars-Cov-2	47
9	Pandemics	93	Sars-Cov-2	230	Education	44
10	Medical Education	82	Students	217	Online Learning	43

Note: O: occurrences.

analysis, the authors utilized an excel sheet with columns for the title of articles, publication's year, author(s), journals, frequent keywords, methodology, key finding(s), and abstract (Salipante et al., 1982).

HOT RESEARCH TOPICS IN DIFFERENT YEARS (2020, 2021, AND 2022)

Table 8 shows the top 10 keyword occurrences in 2020, 2021, and 2022. The minimum number of occurrences was set to

10 for a keyword in the article for 2020, 2021, and 2022 so that the authors focus on the prominent keywords only. The authors would extract 97 out of 2407 keywords, 248 out of 6146 keywords and 44 out of 1951 keywords, respectively, and occurrences of the top 10 keywords are shown in **Table 8**. E-learning is the hottest topic in this field, with the highest occurrences (258, 927, and 111) in 2020, 2021, and 2022, respectively. The e-learning keywords are most famous, with 927 occurrences in 2021 because the pandemic was at its peak, and researchers were most devoted to studying this field.

CONCLUSION AND RECOMMENDATIONS

This study states how the Scopus database was used to explore online learning trends in education during the pandemic using a bibliometric approach. In terms of methodology, the suggested technique may visualize the temporal relationships of the most cited articles within separate streams and offers a comprehensive picture of the evolution of subjects in the Scopus database. Furthermore, citation network analysis enables researchers to study e-learning-related publications and offer a comprehensive summary of the issues raised in the papers.

In perspective of mapping research publications, this piece of research provides an insight into E-learning world. A scientific study was done with 1807 e-learning and COVID-19 documents from 2020 to 2022 that were found through the Scopus database. For most of the researchers and leading institutions, this study identifies emerging trends and contributes significantly in this field as well as prominent sources over period. This study aligns with a number of earlier studies in this field, including Hung (2012), Chiang et al. (2010), Cheng et al. (2014), Fatima and Abu (2019), Tibaná-Herrera et al. (2018), Mashroofa et al. (2020) and Bai et al. (2020). Nevertheless, this research depends on a variety of software to analyze diverse models and networks of E-learning and COVID-19. According to the analysis data, growth trends in research publications in various forms of e-learning and COVID-19 have drastically increased in recent years, particularly in 2 years (1184 in 2021 and 283 in 2022). 2021 was a peak time of COVID-19, so researchers found alternatives of traditional method to e-learning during COVID-19. The following are the significant findings of the bibliometric analysis: the prominent authors in this field are as follows: Stuby L., Suppan L., Suppan M., Harbarth S., Sharma S., Gartner B. and Purwanto A.; The King Abdulaziz University from Saudi Arabia is the most-frequently cited institution in this field of study; with respect to citations and publications, the United States leads the world; and during COVID-19, education drastically transformed into the e-learning mode and has developed into a recent research trend for many researchers.

This research investigated at a highly access topic, that is one of the hot topics right now "e-learning and COVID-19 in education" employed a bibliometric analysis of 1807 articles published in the Scopus database from the years 2020–2022. The authors determined that the sample of the study should be larger; additional studies and a longer time frame are required, particularly when analyzing citations, and research on this topic would be more explored in the future domain.

All the above findings of the study state that the developed countries quickly focused on e-learning method during COVID-19 but developing and less developing countries could not easily shift from traditional to e-learning processes. The reason behind it, that developed countries have been compatible with e-learning process because technology and digital tools were available easily but developing countries and less developed countries did not have proper resources for implementing the e-learning process during COVID-19 and other critical conditions.

This study indicates that the e-learning process mitigates environmental degradation through less paper use. The traditional education method is renowned for overusing "busy work," which is a major cause of paper waste. Even the energy and materials used to recycle paper are reduced when students teach online (Irfan et al., 2021). Before COVID-19 transports services had an adverse effect on environmental quality (Sun et al., 2021), but E-learning eliminates the negative environmental effects of manufacturing and transportation services during COVID-19. The traditional educational methods required (textbooks, desks, electricity, and buildings) are drastically decreased through the e-learning method, which also reduced waste and protects natural resources. Finally, this study majorly contributes to society at all levels of education during COVID-19. There are mainly three key contributions of this study to society. First, this study suggests that developing and less developing countries can upgrade technology and digital tools (Internet, Digital devices and broadband connections etc.,) for e-learning education reached to the lower section of the society. Second, environmental degradation is a major issue across the world, e-learning improve the quality of the environment, so governments should initiate an awareness program about the advantages of e-learning education. Third, developing and less developing countries are unable to provide education to everyone in the lower section of the society, the reason behind this is that low income of the people, less infrastructure, and fewer transportation facilities, e-learning methods reduce the cost of education and deforestation. So all these countries should implement e-learning methods to improve the literacy rate.

There are certain limitations of this study. First, the authors gathered data from Scopus only, which does not include all academic article such as Web of Science and other journal databases. Second, the most recent articles (those published till 18 March 2022) that have been accepted but not indexed in Scopus were omitted. However, such limitations are unlikely to have an impact on the findings of this study.

AUTHOR CONTRIBUTIONS

YA wrote the introduction, MA designed the research and wrote Introduction and Literature Review, MS collected data, processed data in VOSviewer and R Studio, analyzed data, wrote sections: Research Methodology, Results, and Discussion, Conclusion, MA arrange the funding, NH wrote Introduction and Literature Review, MH collected data and NZ supervised the research.

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