



# ColomboArts

Journal of Social Sciences and Humanities

Volume 8 | Issue II

2023



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## A Bibliometric Study on the Evolution of Online Learning during COVID-19

**H. P. K. N. Hewawasam<sup>1</sup>, P. D. Wijesekara<sup>2</sup>**

<sup>1</sup>Department of Criminology and Criminal Justice, Faculty of Humanities and Social Sciences, University of Sri Jayewardenepura, Sri Lanka.

<sup>2</sup>International Center for Multidisciplinary Studies, Faculty of Humanities and Social Sciences, University of Sri Jayewardenepura, Sri Lanka.

Corresponding Author, [pdwijesekara@sjp.ac.lk](mailto:pdwijesekara@sjp.ac.lk)

### Recommended Citation

Hewawasam, H. P. K. N., Wijesekara, P. D. (2023). A bibliometric study on the evolution of online learning during COVID-19. *ColomboArts Journal of Social Sciences and Humanities*, 8(II), 19-46.

Available at: [https://colomboarts.cmb.ac.lk/?page\\_id=672](https://colomboarts.cmb.ac.lk/?page_id=672)

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**Hewawasam, H. P. K. N.**

University of Sri Jayewardenepura  
[kaushi@sjp.ac.lk](mailto:kaushi@sjp.ac.lk)

**Wijsekara, P. D.**

University of Sri Jayewardenepura  
[pdwijsekara@sjp.ac.lk](mailto:pdwijsekara@sjp.ac.lk)

### Abstract

*Online learning, e-learning or online education encompasses the same concept that underwent rapid development and optimization during the COVID-19 pandemic. COVID-19 directly affected the global education landscape and the need for social isolation acted as a catalyst for most schools and education institutes to continue teaching, learning and assessment adopting new technology. Bibliometric analysis is a quantitative approach to analyzing the contribution toward the development of scientific literature. This study aims to portray the publication trends in online learning during the COVID pandemic using bibliometric analysis. The Scopus database was used to obtain the data for the study. The Biblioshiny package and VOS Viewer tool were used for the statistical analysis and graphical modeling. Using the key terms “COVID-19” AND “e-learning OR Online education OR Online learning”, a total of 1105 articles (date of acquisition: 17th January 2023) from 2019-2022 were refined. All the publications were written in English and unpublished articles were excluded. The results depicted that 1) scientific production related in the field increased after 2020 and grew continuously; 2) the literature covers 93 countries worldwide and Indonesia was the country that produced the most literature since 2019; 3) COVID-19– 261(7%), Pandemic – 201(5%), e-learning and human – 200 (5%) were the high-frequency keywords; 4) curricular and learning environments were noted as the emerging themes; 5) the Journal of Sustainability produced the most number of articles; and 6) the co-occurrence of keywords revealed seven clusters which intricate interconnections among diverse domains. Results denoted that online learning platforms have grown in various disciplines during the COVID pandemic. Most important disciplines are related to evolving tools, the need for advanced medical education, psychological well-being and public health challenges during times of widespread crisis. This study serves as a foundation for informed decision-making and strategic planning in the realm of online education.*

**Keywords:** *Bibliometric analysis, Biblioshiny, COVID-19, Online learning, VOSViewer*

## 1. Introduction

COVID-19 was declared as a global pandemic in March, 2020 (WHO, 2020) marking a huge collapse of all trade, and economic, educational, and social activities across the globe. Educational systems in over 190 countries worldwide experienced severe disruption during the pandemic (Almahasees, Mohsen & Amin, 2021) causing educational policymakers to reconsider the modes of continuing work in educational institutions. According to the World Economic Forum (2021), more than 1.2 billion children across 186 countries were affected by school closures due to the pandemic. Further, UNESCO (2021) revealed that more than 0.22 billion tertiary-level students around the world were affected by the pandemic. This disruption in education systems led to various challenges including the loss of learning time, and the negative impacts on the overall well-being of students. Many countries had to adapt to remote learning and implement various measures to mitigate the negative impacts of prolonged school closures.

Disruption to in-person teaching and social distancing regulations necessitated a shift to emergency remote teaching (ERT) (Shin & Hickey, 2021), which challenged the whole education system from kindergarten to higher education. This was because there was no prior preparation or training to adapt to ERT. In addition to teaching and learning, the evaluation of student performance was also done using online platforms. The traditional timed examinations that were typically conducted in lecture rooms could not be done due to issues related to logistics, fairness, and security (Bashir et al, 2021). In such a context, online learning came to the rescue and facilitated the continuation of education systems worldwide. As a result, online educational technologies experienced a substantial upswing in both assimilation and innovative advancements, culminating in a multitude of noteworthy outcomes.

Online learning, also known as e-learning, online education or virtual education, refers to the process of acquiring knowledge, skills, or information through digital resources and the internet. Students are thus allowed to access and engage with learning materials, lectures, assignments, and assessments through online platforms and tools. The shift from on-site to online learning created a 'new normal' globally (Li, 2022). Online learning technologies had been around for quite some time before COVID-19, but their widespread and transformative impact on education became particularly evident after the pandemic. Thus,

new trends in educational systems served to mitigate unrest among socially isolated groups and additionally enabled school-aged children to pursue uninterrupted education.

Amidst the COVID outbreak, researchers across the globe conducted various studies on adaptable online learning modalities which led to novel insights into the realities of online learning. In this study, we investigate the progression of online learning throughout the COVID-19 pandemic through a thorough analysis of scientific literature.

We believe that the insights gained from the period of the pandemic will influence the future of education. Blended learning models that combine online and in-person instruction will become more prevalent, offering the benefits of flexibility, personalized learning, and improved engagement. On the other hand, online learning has challenged both learners and educators in several aspects. However, it is crucial for educators and policymakers to identify the challenges during the COVID-19 to ensure that online learning remains accessible, equitable, and effective for all learners. The pandemic caused scholars and education institutions to engage more in research related to online learning and teaching mainly to discover effective tools and methods of increasing efficiency and to identify the best practices to maintain the quality of online learning.

Despite the fact that the pandemic opened up new windows for the academic community to engage in research in various domains such as technology, medicine, psychology, geography, and education, there remains a need for a comprehensive understanding of the trends that emerged with the pandemic, the patterns of knowledge dissemination during the pandemic, and a thematic analysis of the online learning related literature.

The ultimate aim of this analysis is to inform educators, policymakers, and stakeholders of the current state of research, to highlight areas for future investigations, to facilitate evidence-based decision making, and to enhance the accessibility and effectiveness of online learning in the post-pandemic era.

With this objective, this study will comprehensively map the overall picture of online learning during the COVID-19 pandemic in a global context and examine the developmental dynamics and trends in the field. Thus, the research questions of the study are as follows:

- i. What is the annual trend of publications in online learning research during the COVID-19 pandemic?
- ii. What are the most cited research papers on online learning during the COVID-19 pandemic?
- iii. Who are the most prolific authors in online learning research during the COVID-19 pandemic era?
- iv. What are the most prolific journals in online learning?
- v. What are the most productive countries in researching online learning?
- vi. What are the most frequent keywords and co-occurred keywords related to online learning?
- vii. What are the frontier themes of online learning?

## **2. Literature Review**

Online learning experienced a significant surge during the COVID-19 pandemic (Li & Pei, 2023). With the closure of schools, universities, and various educational institutions to prevent the spread of the virus, educators and learners worldwide turned to online platforms to continue education remotely. This era highlighted both the advantages and challenges of online learning. Online learning platforms such as Learning Management Systems, blogs, discussion boards, wikis, and many websites were popularly used for online learning activities.

The most positive impacts on students' academic performance were observed when considering their behavioural engagement in online learning and their patterns of interaction with Learning Management Systems (LMS) (Cerezo et al., 2016; Kokoç, 2019). Blogs, discussion boards, wikis, and 3D virtual worlds gained both positive and negative feedback according to the learners' experiences (Gregory & Bannister-Tyrrell, 2017). Many online learning platforms have become popular after the pandemic and learning via online learning websites such as Coursera, Udemy, Skill Share, edX, and LinkedIn has become popular. Synchronous (real-time) and asynchronous (self-paced) communication options are the main sources of communication used in online learning. Synchronous (real-time) communication modes include Live chats, Webinars, video conferencing tools, live chats, social networking sites, and virtual and augmented realities. Asynchronous communication includes pre-recorded lectures, podcasts, blogs, wikis, e-portfolios, emails, and discussion

forums (Dailey-Hebert, n.d.; Beatty, 2019). Online learners are allowed to choose their preferred tools of learning among the many options available (Gregory & Bannister-Tyrrell, 2017).

Key features of online learning include flexibility: Online learning allows learners to access course materials and engage in learning activities at their own pace and convenience. Learner-centric aspects, including time, location, available learning materials, interaction opportunities, and the speed of learning are the most significant dimensions that contribute to flexibility in e-learning (Li & Wong, 2018). This flexibility is particularly beneficial for individuals with busy schedules or those who cannot attend traditional in-person classes. The second feature is accessibility: Anyone with an internet connection can participate in online learning, making education available to a global audience. This inclusivity opens up opportunities for people who might not have access to traditional educational institutions. Also, online learning is accessible to all individuals including people with disabilities. Accordingly features such as facilitating screen readers, providing Alt text for low-vision students, and providing captions for hearing-impaired students increase their accessibility to quality online education (Mc Alvage & Rice, 2018). Thirdly, there is interactive content: Modern online courses often include interactive elements such as audio, videos, quizzes, discussions, screen sharing ability, virtual hand raising, and simulations. These features cater to different learning styles and enhance engagement and understanding (Dailey-Hebert, n.d.; Sweetman, 2020). Fourthly, it allows self-directed learning: Online learning encourages learners to take control of their education. They can set their own study schedules, choose which materials to focus on, and revisit content as needed (Khodaei et al., 2022; Li & Wu, 2023; Maphalala et al, 2021). The fifth feature is cost-effectiveness: Online courses can be more affordable than traditional education, as they eliminate the need for commuting, physical facilities, and printed materials. This cost-effectiveness is advantageous for both learners and institutions. The sixth feature is the opportunity to network with peers and experts: Online learning provides opportunities to connect with peers and instructors from around the world, fostering a diverse and international learning community (Shekhar & Shailendra, 2021). The 7<sup>th</sup> feature is breaking down geographical barriers: Online learning has transformed traditional educational methods by breaking down geographical barriers and providing a wide range of courses, from formal academics to skill-based training. As the final feature, online platforms offer a diverse array of courses, ranging

from academic subjects to professional certifications, language learning, and even hobbies. Learners can choose subjects that align with their interests and goals and also according to financial affordability. Unlike formal education, online learning platforms offer a wide range of skill-based courses that help individuals enhance their professional and personal skills (Finch & Jacobs, 2012).

However, misuse of technology, lack of adaptation to effective online teaching methods, lack of proper assessment and evaluation process (Debeş, 2021) and insufficient infrastructure (Masalimova et al., 2022) are noted as drawbacks of online learning. Also, online learning lacks the social interactions and personal connections that traditional classrooms offer, potentially impacting students' mental and physical well-being (Vaillancourt et al., 2022). Especially, the socialization process of the school-aged is interrupted as onscreen learning produces physically inactive students.

Concurrently, academics and specialists within the domain have discerned the challenges inherent in online learning, subsequently elucidating solutions to overcome these issues to some extent. Using low-cost hardware, compressing lessons, employing mobile vans equipped with computers and internet access through 3G/4G portable router access points, leveraging ad-hoc digital networks, and doing skills training for youth in low bandwidth areas are some of the solutions proposed to encourage online education (Datta, Jakimowicz & Singh, 2021). Establishing a study routine to maintain consistency (Scutelnicu et al., 2019); actively participating in discussions and engaging with course materials (Hollister, 2022); managing time effectively (Batbaata & Amin, 2021; Hassan, Zaheer & Khalid, 2021); communicating with instructors and fellow learners to clarify doubts (Dickinson, n.d.; Alawamleh, Al-Twait & Al-Saht, 2020), and staying motivated and setting clear learning objectives (Al-Hashmi, 2021; Hartnett, 2016) are the key concerns of engaging in effective online learning. However, it is important to note that while online learning offers numerous benefits, it also requires self-discipline and a certain level of digital literacy to navigate online platforms and tools effectively.

The COVID-19 era underscored the importance of flexible and adaptable educational systems. It prompted educational institutions to invest in improving their online infrastructure, training educators in effective online teaching methods, and finding ways to bridge the digital divide (Navarro & Mcgrath, 2022). It also highlighted the significance of

a balanced approach that incorporates both online and in-person learning, taking advantage of the benefits of each (Rensburg, 2018).

Zhou (2023) has done a bibliometric analysis relating to online education in sports. The data was obtained through the WOS database (Web of Science Core Collection) and 229 papers have been used for the study. Through the study, the author has identified the information of the authors, keywords, and number of publications. Further, Cruz-Cárdenas et al. (2023) presented the paper titled “Blended learning and higher education: A bibliometric analysis”, and the study was centered on 2,477 relevant articles in the Scopus database. The study focused on 1) the challenges and opportunities that COVID-19 posed, 2) the effectiveness and performance of blended learning, 3) the organization and design of blended learning, and 4) the technological tools and forms of delivery of blended learning. Djeki et al. (2022) conducted a bibliometric analysis using 12,272 publications between 2015 and 2020 from the WoS database. They identified the USA, Spain, England, and China as the most productive and influential countries in online learning. *Computers in Human Behavior*, *Computers & Education*, and *International Journal of Emerging Technologies in Learning* were identified as the most represented journals, while the Islamic Azad University, Universidade Nova de Lisboa, and King Abdulaziz University were identified as the most influential universities in the domain (Djeki et al., 2022). Sobral (2021) has also done a bibliometric analysis of two decades of research in e-learning. The study attempted to analyze the scientific production of e-learning in journals indexed on Elsevier's Scopus. The sample composed of 25330 articles from 2000 to 2019. Lin & Yu (2023) conducted a bibliometric analysis on peer assessment in online language courses using the data from the Web of Science (WOS), and they used several sources including the Science Citation Index Expanded (2013-2023), Social Sciences Citation Index (2006- 2023), Arts and Humanities Citation Index (2008 - 2023), and the Emerging Sources Citations Index (2017- 2023). Davy, Anthony & Sau, (2023) studied 920 papers from the Scopus database for exploring key research themes of management education and online learning. According to their study, European countries accounted for the largest proportion of the listed publications. Additionally, pedagogy, technology, assessment methods, learning outcomes or skills, and challenges were identified as the key areas that scholars frequently focused their attention on. Talan & Demirbilek (2022) conducted the study titled “Bibliometric analysis of research on learning analytics based on Web of Science Database”, and they used a total of 659



publications on the subject between the years 2011-2021. Through this study, they found that the most influential countries in the field of learning analytics are the USA, Australia, and Spain. The University of Edinburgh and Open University UK ranked first in terms of the number of citations and Monash University was the most prolific institution in terms of the number of publications (Talan & Demirbilek, 2022). Following the literature, it is clear that different scholars have identified bibliometric analysis relevant to defining the outlines of online teaching and learning. There exists a lack of research in outlining bibliometric analysis to define the concepts and trends of online learning and teaching strategies in the COVID-19 era. Thus, this study will imply the most influential and important information on the particular field during that period.

### **3. Methodology**

Bibliometric analysis is a quantitative research method that involves the analysis of bibliographic information from scholarly publications to gain insights into various aspects of scientific research, academic disciplines, authors, journals, and more. It is commonly used in the field of scientometrics, which focuses on studying the structure and dynamics of scientific research and scholarly communication. Bibliometric analysis typically involves collecting and analysing data from various sources, such as academic databases, to uncover patterns, trends, and relationships within the scholarly literature (Linnenluecke et al., 2020). Further, it provides valuable insights for researchers, institutions, publishers, and policymakers to make informed decisions about research funding, collaborations, journal rankings, and more. However, it is important to note that while bibliometric analysis can provide quantitative data, it may not capture all nuances of scholarly impact and quality.

#### **3.1 Data Sources**

The Scopus database which includes a comprehensive collection multidisciplinary data was used as the source of data. As the COVID pandemic immersed in 2019, the articles from 2019-2022 were considered for the study. After refining, 1105 documents on online learning were selected for the analysis. Data was retrieved on the 17<sup>th</sup> January 2023. The following are the criteria for selecting the dataset.

Database: Scopus

Search terms: “COVID-19” AND “e-learning OR Online education OR Online learning”

Language: English

Document type: Articles

Period: 2019-2022

### **3.2 Research Method**

Bibliometrix and Biblioshiny tool packages programmed in R software language were used for the analysis and visual displays (Aria & Cuccurullo, 2017). Biblioshiny allows users to perform visual analysis on an interactive web interface. VOSviewer tool, developed by Nees van Eck and Ludo Waltman (Van Eck & Waltman, 2010), was used for visualising scientific landscapes. Co-word analysis, co-citation analysis, and co-authorship analysis by country were interpreted using the VOSviewer tool.

## **4. Analysis**

The total number of documents recognized was 1105. The average document age which suggests the recency of the literature in the field was 0.652. It highlights that the literature is relatively recent. Considering the above period, the average number of citations per document was 11.77%. The total number of authors who have contributed to publications is 4090 and 2277 keywords were used. The number of publications published as individual authors is 116. Accordingly, the most prominent feature of the related studies was that a large number of research papers had appeared as collective publications.

### **4.1 Distribution of Annual Documents**

Figure 1 presents the number of research papers and academic output related to online learning between 2019 and 2022. From 2019 to 2022, the number of declared research documents on online learning had clearly increased.

Accordingly, only one research paper appeared in the year 2019 (the year that marked the beginning of the pandemic). However, the number of publications has grown up to 125 by the year 2020.

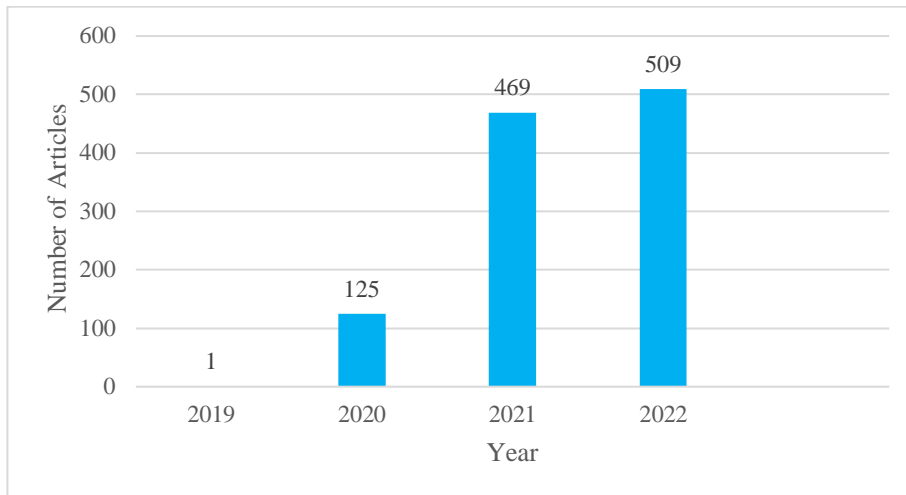


Figure 1: Number of published research documents on online learning.

Source: Compiled by the authors.

The number has increased by 344 documents by 2021, and 40 documents by 2022, the related research papers have grown further. It is clear that these research papers have developed with the impact of the COVID pandemic. This was because online technology was a new experience in many developing countries, and many researchers developed various methods to reach the optimum output of online learning. The rapid growth observed between the years 2019 and 2022 is indeed a notable and significant trend.

## 4.2 Analysis of Cited Papers

### 4.2.1 Analysis of the Annual Development Trend of Citations

With the increase in scientific publications, references and citations in the related research have increased drastically. Figure 2 shows the annual count of citations for the research related to online learning, which depicts a growing trend. The growth of citations demonstrates that it is built upon a solid foundation of existing knowledge. Accordingly, though there was only one citation in 2019, the number of citations has grown steadily since 2020 (125), with 469 citations in 2021, and 509 in 2022.

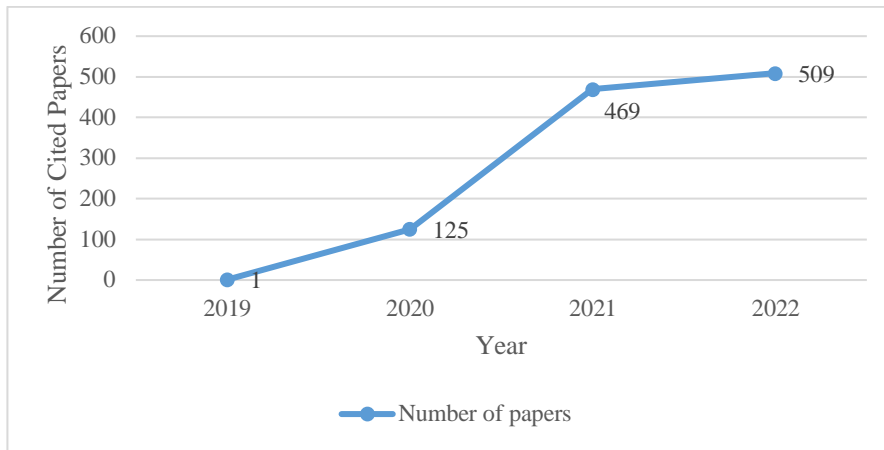


Figure 2: Annual Citation Trend  
Source: Compiled by the authors.

Among the highly cited research papers, ‘Advantages, limitations and recommendations for online learning during COVID-19’ by Khadijah Mukhtar (2020) should be appreciated. His research paper has received the most citations (362) throughout the period. The average total citation count per year was recorded as 120.67 for Mukhtar (2020). It was noted that all the 10 most cited papers were published in 2020 (Table 1).

#### 4.2.2 Analysis of the Top 10 Local Citations

Table 1: Top 10 Local Citation Scores

Paper	DOI	Total Citations	Total Citations per Year	Normalised Total Citations
<b>Mukhtar K, 2020,</b>	10.12669/pjms.36.COVID19S4.2785	362	120.67	7.32
<b>Almaiah M. A. et al, 2020</b>	10.1007/s10639-020-10219-y	345	115.00	6.98
<b>Aguilera-Hermida A.P, 2020</b>	10.1016/j.ijedro.2020.100011	337	112.33	6.82
<b>Khalil R. et al, 2020</b>	10.1186/s12909-020-02208-z	258	86.00	5.22
<b>Favale T. et al, 2020</b>	10.1016/j.comnet.2020.107290	249	83.00	5.04
<b>Rasmitadila R. et al, 2020</b>	10.29333/ejecs/388	233	77.67	4.71
<b>Abbasi S. et al, 2020</b>	10.12669/pjms.36.COVID19S4.2766	229	76.33	4.63
<b>Mailizar, 2020</b>	10.29333/EJMSTE/8240	227	75.67	4.59
<b>Hasan N, 2020</b>	10.1016/j.childyouth.2020.105355	220	73.33	4.45
<b>Dong C, 2020</b>	10.1016/j.childyouth.2020.105440	208	69.33	4.21

*Note: Local citation is derived within the Scopus database.*

Source: Compiled by the authors.

### 4.2.3 Citation by Documents

Figure 3 presents the cooccurrence of the research papers that are mostly co-cited. Purple coloured bubbles in the graph show that most of the research papers produced in the year 2020 have received the highest citations. Accordingly, Khalil et al. (2020), Mailizar et al. (2020), Mukhtar et al. (2020), Almaiah et al. (2020), Aguilera– Hermida (2020), and Dong et al. (2020) have received the highest number of citations in 2020. It is notable that the researchers such as Tang et al. (2021), Lemay et al. (2021), Baticulon et al. (2020, and Shahzad et al (2021) have obtained citations for their research presented in the year 2021 (green coloured bubbles).

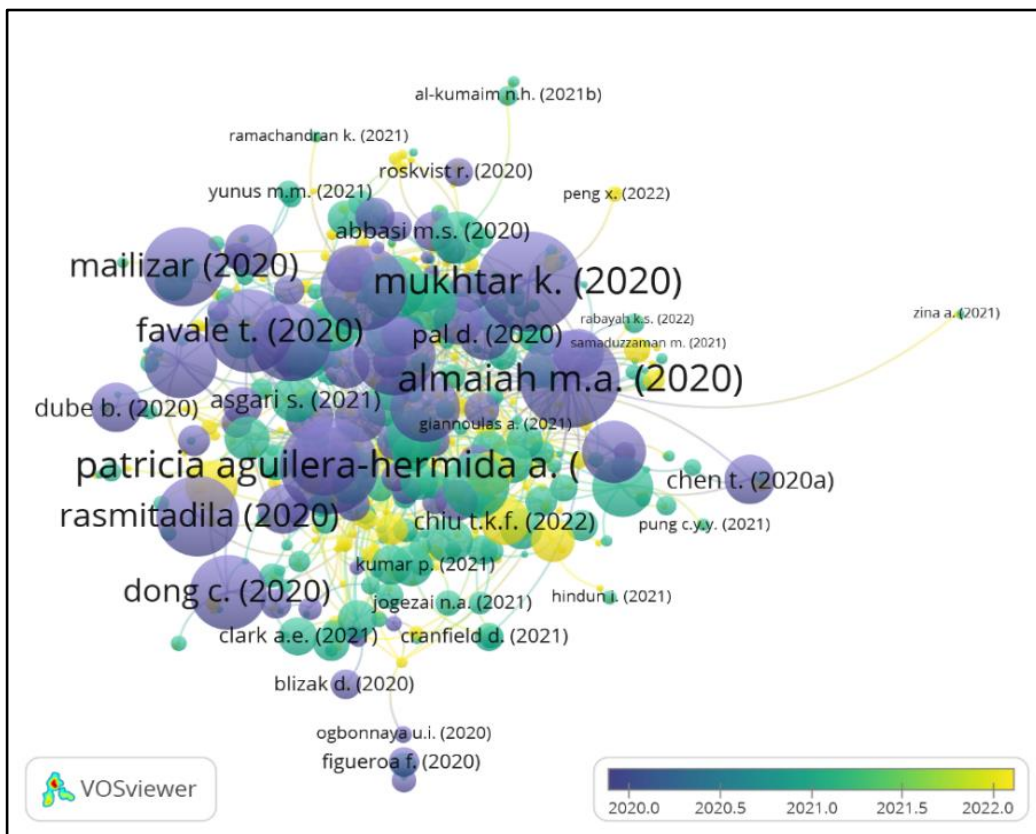


Figure 3: Cooccurrence network of highest citations

*Note: Figure 3 is generated using the overlay visualization tool of VOS viewer.*

Source: Compiled by the authors.

### 4.3 Analysis of Most Prolific Authors

#### 4.3.1. Top 10 Influential Authors

Table 2 presents the authors who have contributed the most to the field of online learning in the year 2021 and have produced high-value research papers. Author Yang J. has obtained the most citations (292) for 5 publications. Further, Professor Su Yu Sheng from Taiwan was noted as the next most influential author with 143 citations for 6 publications.

Table 2: Top 10 Influential Authors

Author Name	h_index	g_index	m_index	TC	NP	PY_start
Su Y-S	5	6	1.667	143	6	2021
Zhao L	5	7	1.667	49	7	2021
Hong J-C	4	5	1.333	34	5	2021
Lin C-L	4	4	1.333	136	4	2021
Liu X	4	5	1.333	31	5	2021
Liu Y	4	5	1.333	32	7	2021
Yang J	4	5	1	292	5	2020
Baber H	3	3	1	99	3	2021
Elshaer IA	3	4	1.5	21	4	2022
Jin YQ	3	3	1	90	3	2021

*Note: TC- Total Citation, NP – Number of Publication, PY – Publication Year.*

Source: Compiled by the authors.

#### 4.3.2 Authors' Production over Time

A further examination on this topic makes it incontrovertible that various scholars have engaged in academic writings with greater impact in different contexts. Uncovering authors' production over time also helps to identify the time spans where the authors actively participated in scholarly work.

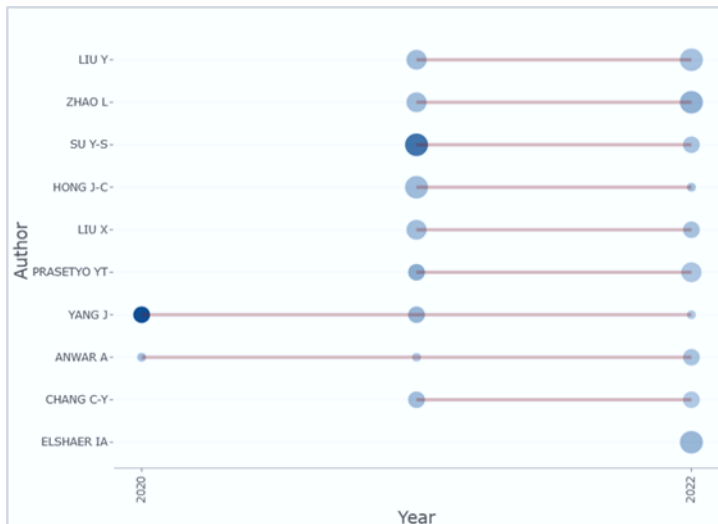


Figure 4: Authors' production over time.

Source: Compiled based on Biblioshiny software

Accordingly, in the year 2020, the author Liu Y. (Associate Professor Ying Liu) of Zhengzhou University of China managed to make a greater impact since 2021. He authored 7 publications and co-authored papers titled “Disciplinary differences in the experience of online education among teachers and students in Chinese universities during COVID-19” (2022) and “Associations between online learning, smartphone addiction problems, and psychological symptoms in Chinese College students after the COVID-19 pandemic” (2022) were highly valued. He has obtained a total of 32 citations during this period. The authors Yang J. and Anwar A. have contributed through their academic writings since 2020.

Professor Su YS (Su Yu-Sheng) is also a significant author because of the high number of published documents (6) and the highest frequency of average citations per item. His co-authored paper titled “Continuance intention of university students and online learning during the COVID-19 pandemic: A modified expectation confirmation model perspective” in 2021 obtained a total of 46 citations with 15.33 total average citations per year. Further, his paper titled “Factors influence students' switching behavior to online learning under COVID-19 pandemic: A push-pull-mooring model perspective” (2021) has obtained 36 total citations and 12 average total citations count per year.

## 4.4 Most Prolific Journals

### 4.4.1 Most Published Journals

The most productive journals and the number of publications that they have produced regarding online education during the COVID -19 pandemic are presented in Figure 5.

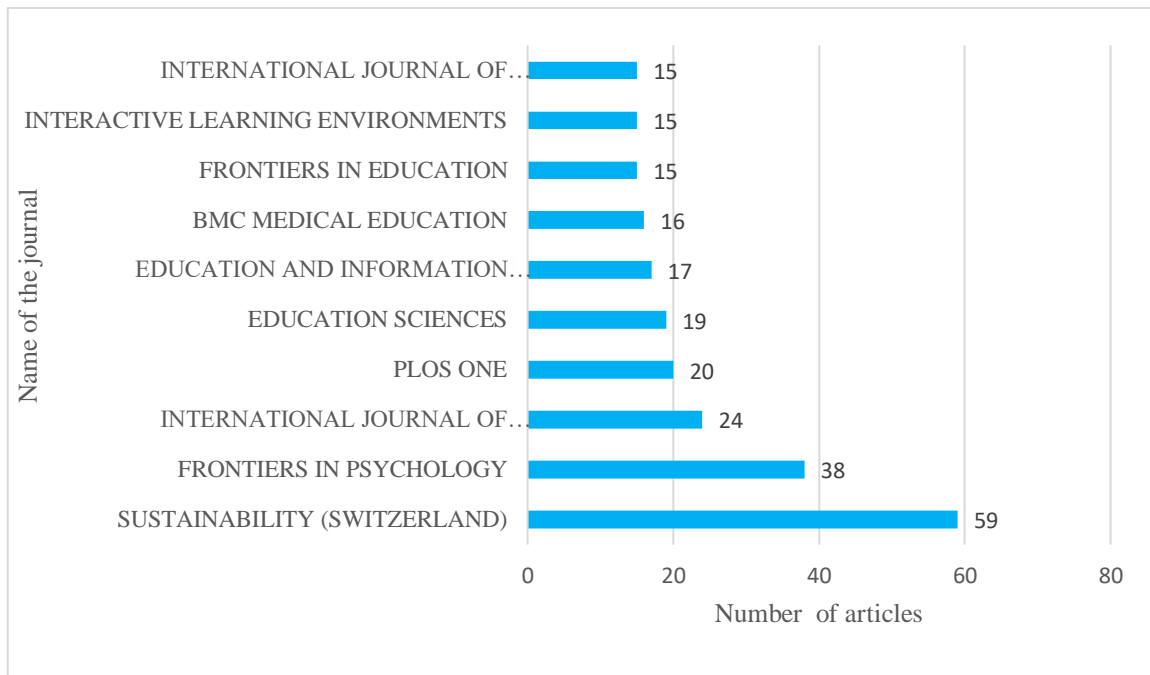


Figure 5: Most published journals.

Source: Compiled based on Biblioshiny software

Suitably, more research papers have been published in the *Journal of Sustainability* (59), *Frontiers in Psychology* (38), *International Journal of Environment Research and Public Health* (24), *Plos One* (20), *Education Science* (19), *Education and Information Technology* (17), *BMS Medical Education* (16), *Frontiers in Education* (15), *Interactive learning Environments* (15), and the *International Journal of Emerging Technologies in Learning* (15).

### 4.4.2 Most Cited Sources

The citation count underscores the substantial influence and recognition attributed to the domain within the academic and research community.



Table 3: Most Globally Cited Sources

Sources	Articles
Computers & Education	583
Sustainability	462
Computer Education	418
Computers in Human Behavior	404
The Internet and Higher Education	291
Education and Information Technologies	259
Distance Education	229
Computer and Human Behavior	207
British Journal of Educational Technology	206
Plos One	203
BMC Med Educ	202
Computers and Education	165
IEEE Access	163
Mis Quarterly	163
Education Information Technology	148
Journal of Educational Technology Systems	142
Interactive Learning Environments	135

Source: Compiled by the authors.

Table 3 presents the journals that have been mostly cited among the scientific community on the above topic. Accordingly, the *Journal of Computers and Education* garnered the highest count of citations, totaling to 583 instances. The second place is held by the *Journal of Sustainability* (462 citations). Also, *Computer Education* has 418 citations. Additionally, *Journal of Sustainability* acts as a hub for the dissemination of knowledge in this domain of research. Other than the quantity of the publications produced, the number of citations represents the quality of the articles they publish.

## 4.5 Production by Country

### 4.5.1. Co-authorship by Country

Figure 6 depicts how the research networks in this domain are spatially spread. Accordingly, it is clear that there are several research networks. Mainly Indonesia, Australia, Hong Kong, Malaysia, Taiwan, and Vietnam collaborate with each other. Another collaboration network is visible from the European region where the collaborations come from Spain, Germany, France, United Kingdom, Italy, and Ireland. The Middle Eastern region collaboration network is composed of Saudi Arabia, Egypt, Palestine, and Oman. Also, it is apparent that

countries such as the United States, Sri Lanka, Peru, Israel, Canada, and Namibia possess an outstanding research network. In addition, it is coherent how the research networks of investigators have spread across states.

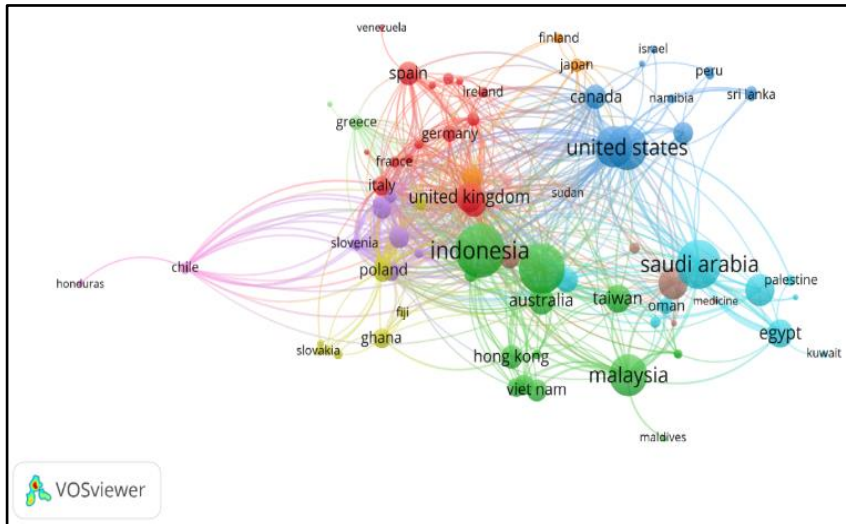


Figure 6: Co-authorship by Country.

Source: Compiled based on Biblioshiny software

#### 4.5.2 Country Scientific Production

Further, country-wise scientific production was tested compared to the year of publication. Figure 7 depicts the countries that produced the most research with the time.

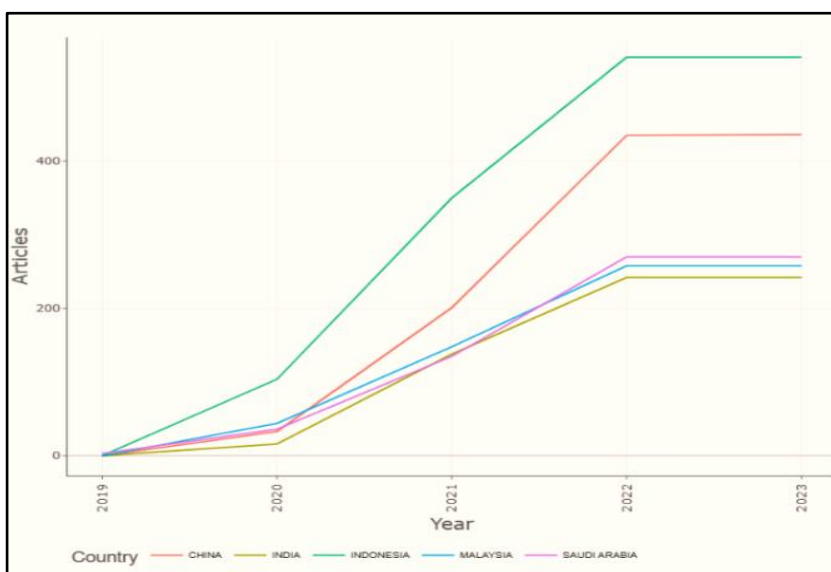


Figure 7: Most Scientific Production by Country.

Source: Compiled based on Biblioshiny software

This diagram reveals that Indonesia has the highest scientific production in studies related to online learning since 2019 (541). Also, China (436), Saudi Arabia (270), Malaysia (258), India (242), USA (226), Pakistan (169), and Jordan (147) have contributed to the growth of the field. Accordingly, county-wise, there is a very high contribution from Indonesia.

## 4.6 Analysis of Keywords

### 4.6.1 Analysis of High-Frequency Keywords

Figure 8 reflects how the keywords are used by the researchers.

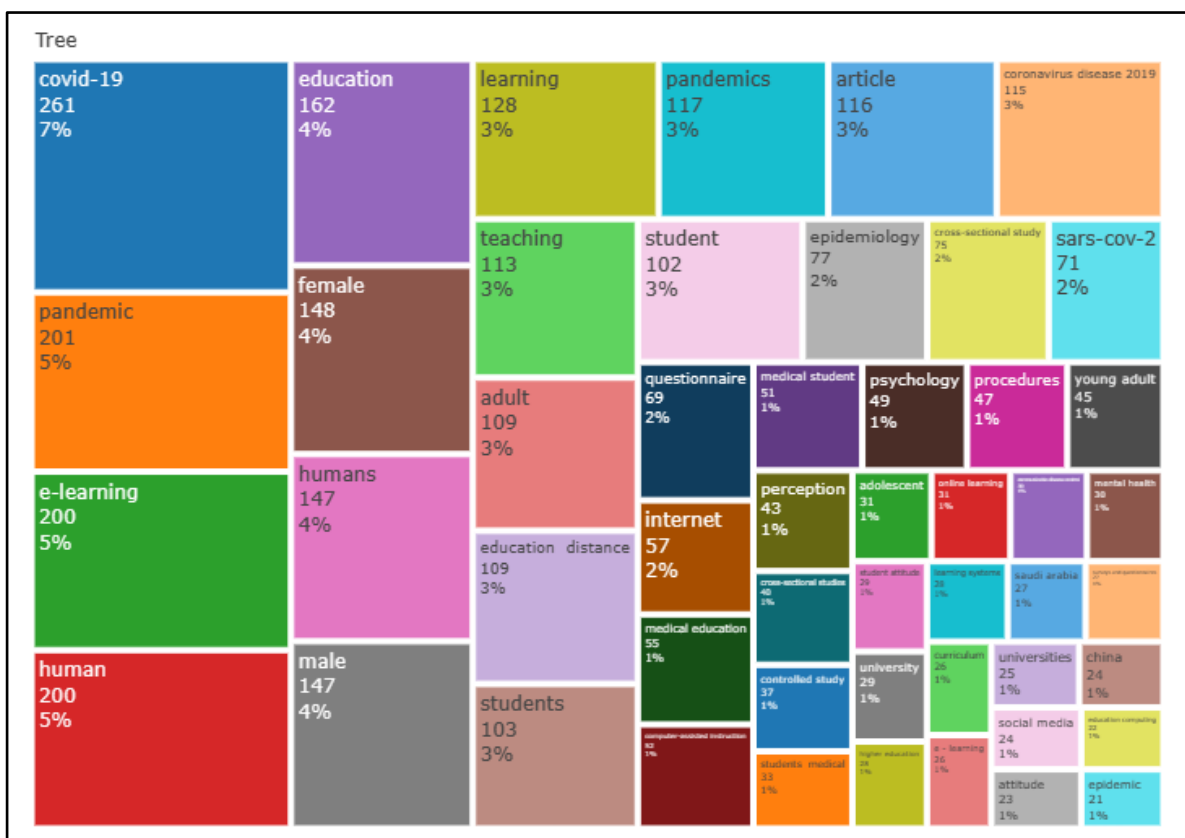


Figure 8: Word Tree.

Source: Compiled based on Biblioshiny software

The researchers have used different types of keywords for their research studies related to online teaching. Accordingly, the most used keyword was COVID-19, 261(7%). Further, Pandemic – 201(5%), e-learning and human – 200 (5%), education – 162 (4%), female – 148 (4%), and humans and male – 147 (4%) have been used.

### 4.6.2 Co-occurrence by Keywords

Co-occurrence analysis is a valuable bibliometric method used to uncover relationships between terms in a given corpus. Each word that cooccurred 5 times or more in the data set was used for the analysis.

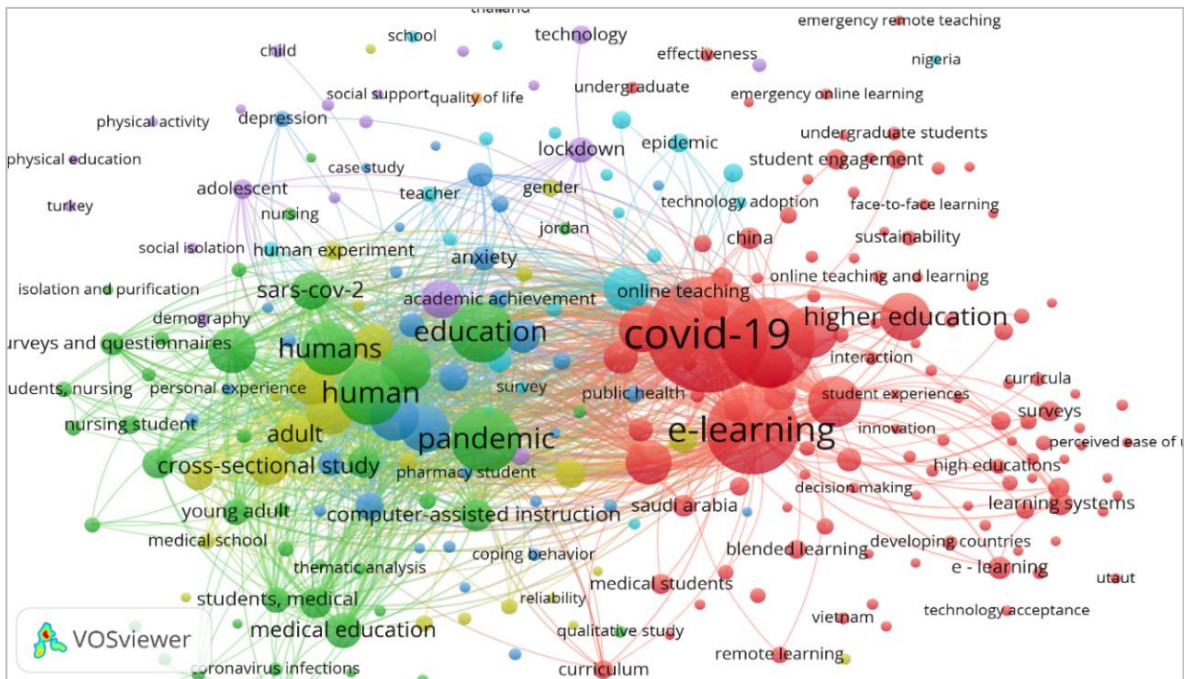


Figure 9: Co-occurrence by All Keywords.

Source: Compiled based on Biblioshiny software

Figure 9 clearly distinguishes how the keywords co-occurred in research papers related to online learning. It presents key clusters of terms that frequently appear together, shedding light on the most prevalent topics within the research domain. 7 clusters appeared from the analysis and a few selected clusters from this illustration are presented in Table 4.

Table 4: Keywords in the clusters

Cluster	Keywords
Cluster 1 (Red)	COVID -19, E-learning, Challenges, China, Blended learning, Learning system, Bangladesh, Computer-aided instruction, Developing countries
Cluster 2 (Green)	Pandemic, education, distance, human, betacoronavirus, medical education
Cluster 3 (Blue)	Mental health, anxiety, Corona disease 2019, epidemic

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Cluster 4 (Yellow)	Cross-sectional study, adult, female, male, satisfaction, medical school, gender
Cluster 5 (Purple)	Technology, sex difference, epidemiology, lockdown, child, high school, social support

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Source: Compiled by authors

This analysis shows how researchers dedicated to studying online learning are spread across states and how their research networks are also spread in different disciplines.

Cluster 1 included 120 items. Cluster 1 of keywords provides insights into the intersection of the COVID-19 pandemic, evolving learning modes, challenges, and the educational landscape in China and other countries (Zhu et al., 2022; Qadriani, 2022; Xiong et al., 2021). The analysis highlights the dynamic nature of education in response to global crises.

Cluster 2 includes 47 items that reflect a multidimensional exploration of how medical education systems responded to the COVID-19 pandemic, balancing the challenges of remote education with the need for maintaining human-centred and patient-focused training (Al-Balas, 2020; Vaca-Cartagena et al., 2023). It emphasises the importance of flexibility, adaptability, and innovative approaches in medical education during times of crisis.

Cluster 3 includes 35 items, it draws attention to the critical intersection of mental health (Zhang et al., 2022; Mukhtar, 2020), anxiety (Wang et al., 2022), and the COVID-19 pandemic. By analysing the co-occurrence of these keywords, researchers can better understand the complex interplay between psychological well-being and public health challenges during times of widespread crisis.

Cluster 4 gathered around the difference in satisfaction among males and females. Further, the term “medical school” indicated the attention drawn to medical education using e-learning tools. Lastly, cluster 5 gathered around the implications of lockdown on the school education of children. Sex differences and technology are also addressed in the related research cluster. Accordingly, conducting a co-occurrence analysis using the keywords offers an opportunity to delve into the focal points and the intricate interconnections among various domains within the realm.

### 4.6.3 Thematic Map of High-Frequency Keywords

Figure 10 exhibits the thematic map related to online learning during the COVID-19 era providing a subsequent understanding of its well-established themes. It provides a clear demarcation of niche themes, motor themes, basic themes, and emerging or declining themes.

Niche Themes: 1. health care and violence; 2. detection method, 3. spatiotemporal analysis, academic research; 4. developing countries, cloud computing; 5. the learning process, online learning environment; 6. teaching and learning, viruses; 6. structural equation modeling.

Emerging and Decline themes: 1. education computing, online system; 2. the higher education system, curricula; 3. learning environment; 4. e-learning; 5. Corona Virus, higher education.

Motor themes: 1. psychology, procedures, students, medical curriculum, education, medical undergraduates, beta coronavirus, middle-aged, nursing students, coronavirus infection; 2. electronic assessments, online questionnaires, and e-learning platform; 3. public attitude, sustainability, Romania, questionnaire survey, world wide web, comparative study.

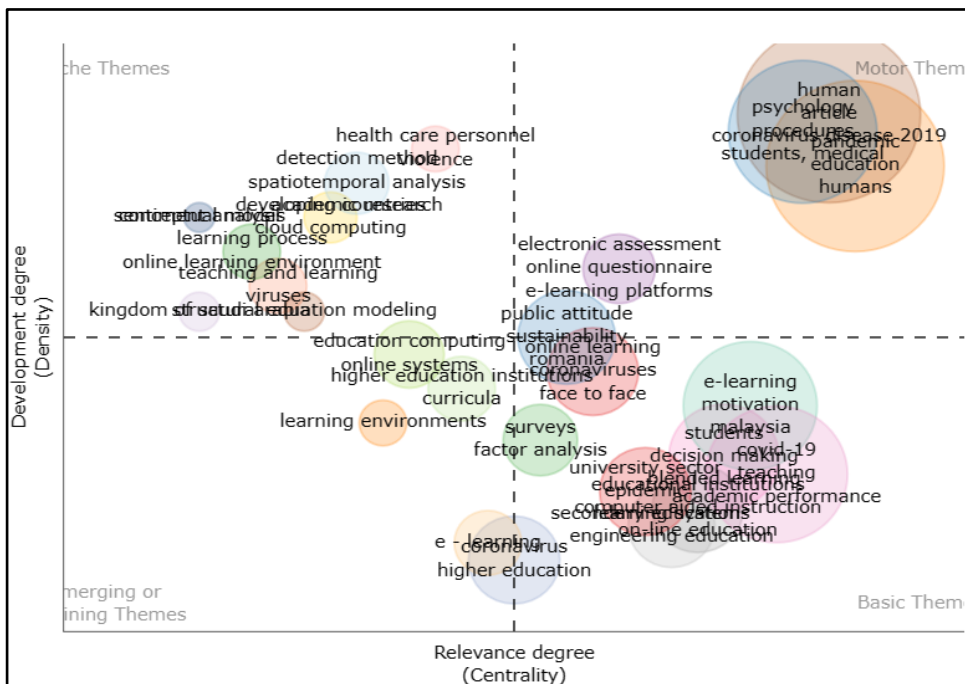


Figure 10: Thematic Map

Source: Constructed based on Biblioshiny software



Basic Themes: 1.online learning, Coronavirus, face-to-face, teachers; 2. survey, factor analysis; 3. student, decision-making, blended learning; 4. university sector, epidemic, secondary education; 5. learning system, engineering education; 6. COVID-19, teaching, academic performance, information and communication technology, Indonesia, postgraduate student, public health, telecommunication, clinical effectiveness; 7. Coronavirus, higher education; 8. educational institution, computer-aided instruction, online education; 9. e-learning, motivation, Malaysia, deep learning, Croatia were the basic themes.

#### 4.7 Conceptual structure

The conceptual structure-function is used to perform multiple correspondence analysis (MCA) to draw a conceptual structure of the field. Multiple correspondence analysis (MCA) is a commonly used sociological approach. It compresses large data with multiple variables into a low-dimensional space to form an intuitive two-dimensional (or three-dimensional) graph that uses plane distance to reflect the similarity between the keywords (Xie et al., 2020).

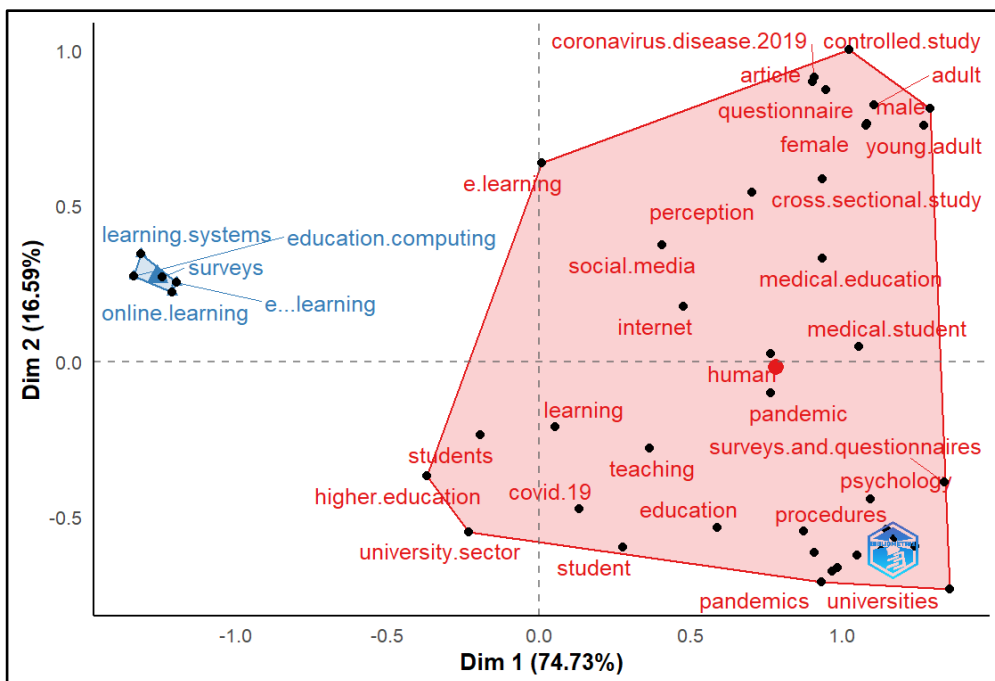


Figure 11: Multiple correspondence analysis (MCA) of high-frequency keywords.

Source: Constructed based on Biblioshiny software

According to the analysis of Figure 11, it is comprehensible that the research studies that have been conducted concerning online education have focused on several main areas. Among these areas, learning system surveys, online learning, e-learning, and education computing are important. Additionally, aspects like e-learning, higher education, university sector, student, adult, Coronavirus disease, and cross-sectional study, are significant.

## 5. Conclusion

The online learning approach has become increasingly popular due to its convenience, flexibility, and ability to reach a wide and diverse audience. It covers a broad spectrum of educational experiences, ranging from formal academic courses to professional development, skill-based training, and even informal learning opportunities. Online learning has the potential to reshape how education is delivered and accessed.

Based on this bibliometric analysis, the following conclusion can be made in line with the objective. Though there were many research studies relevant to online learning and teaching that have continued until 2019, it has developed dramatically from 2020 after the emergence of the COVID-19 pandemic. A total of 1105 research publications are available in this domain. A total of 11.77 citations were reported during the above period. The total number of authors contributing to publications is 4090 which is a very large growth that has taken place within 3 years. Our analysis indicates that the research papers published in 2020 received a large number of citations. Moreover, the *Journal of Sustainability* is vital as it has contributed to the field with the most publications and it has become the third most cited journal. Further, the *Journal of Plos One* has produced the third highest number of articles while being the 10<sup>th</sup> most cited in the relevant field. Indonesia has had the highest scientific production in studies related to online learning since 2019. Being an upper middle-income country, scientific production by Indonesia is comparatively high compared to other countries. Indonesia has produced more scholarly work than developed nations such as China and the USA, which are famous for their research production. A substantial volume of research papers has been produced in the form of collaborative publications. Several key collaboration networks are visible from the Asia-Pacific region, Europe, and the Middle East regions. Keyword co-occurrence in the study originated from several domains. Notably, the need for continuing education systems, giving medical education and



practicing apprentices in the medical field, and psychological well-being and public health challenges were the key concerns of the domains.

This bibliometric analysis sheds light on the prolific research output in the domain of online learning during the COVID-19 era. The study extends beyond the immediate context of the pandemic, influencing educational practices, policies, and technologies for the foreseeable future. Further, this study points to the growing interest and collaborative potential in this field. The study encourages educators, researchers, and institutions to engage in interdisciplinary collaborations to further enhance the understanding and practice of online learning in various implications. Finally, it can be stated that the implications stemming from the investigation into the evolution of online learning during the COVID-19 era are far-reaching and diverse.

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