A BIBLIOMETRIC ANALYSIS OF ONLINE LEARNING IN HIGHER EDUCATION: A COMPARISON OF RESEARCH TRENDS BEFORE AND DURING THE COVID-19 PANDEMIC

Alesksander Aristovnik, Lan Umek, and Dejan Ravšelj
University of Ljubljana, Faculty of Public Administration
SLOVENIA
Konstantinos Karampelas
University of the Aegean, Department of Primary Level Education
GREECE

Abstract

Online learning has a considerable history in higher education, implying that it is not a novel concept. However, with its primary purpose of providing education for those otherwise unable to participate in a traditional learning setting, online learning became an emergency and mandatory mode of learning during the Covid-19 pandemic. Therefore, this paper explores research trends of online learning in higher education before and during the pandemic by applying several bibliometric approaches. The results of the bibliometric analysis reveal differences in research trends before and during the pandemic and provide evidence-based guidelines for supporting higher education in the future.

Introduction

This paper aims to examine the impact that Covid-19 had on research about online learning in higher education. This mode of learning has been studied over the last decades. Education institutions have been using online learning with a rising frequency, as it has been considered an innovation in learning, which brings on new opportunities in knowledge transmission or dissemination. However, until the end of 2019, educators, instructors or policymakers would treat online learning as optional. This changed drastically at the beginning of the year 2020 when online learning was decided as the only option for delivering teaching or instruction due to lockdowns and restrictions. Therefore, it was imposed through the paradigm of Emergency Remote Teaching (Fuchs, 2022).

This forced the implementation of online learning in higher education and triggered the interest of the researchers in that research topic. Studies have shown that there are advantages to using online learning (Dumford & Miller, 2018; Mukhtar et al., 2020; Yuhanna et al., 2020). First, it can provide flexibility in the delivery of education in terms of time and place, leading to greater participation. Second, it

may permit learners to have their own pace in catching up with the requirements of a course, especially in cases of asynchronous teaching. Third, it can provide interaction, mainly through Web applications, that can be embedded in the teaching process (Adedoyin & Soykan, 2023).

However, online learning has significant challenges. Both teachers and students might feel isolated and stressed. To respond to course requirements, they have to demonstrate not only academic qualities but digital competency, as well. Apart from that, there is also a need for appropriate context and infrastructure in educational institutions. These challenges were particularly evident in the case of Covid-19. Since the institutions were obliged to use online learning through Emergency Remote Teaching, the platforms for learning had to accommodate a large number of participants. Aside from that, teachers and students who were not very familiar with digital technologies were obligated to become so (Fuchs, 2022; Maatuk et al., 2022).

Accordingly, this paper aims to point out whether these issues are reflected in the research trends around online learning in higher education before and during the Covid-19 period and reveals the shift towards emergency remote learning. The paper is structured as follows. After the introduction section, the next section presents a short literature review. The following section explains the materials and methods. The next section presents the main results of the bibliometric analysis. The paper ends with a conclusion in which the main findings are summarized.

Literature Review

Online learning at all levels of education has attracted the interest of bibliometric studies over the last decades. Rodríguez Jimenez et al. (2019) aimed to investigate the production of articles relating to using Technologies in Higher Education through the Web of Science database. The researchers gathered 1689 articles from 656 journals published between 1972-2019. However, a surge in the number of publications was observed during the decade of the 2010s, especially on articles that focus on training future teachers and professionals to use technology in their work. According to the researchers, this tendency is expected to continue, while technology would not be considered only as means for teaching but as a stimulus for new ideas and ways of thinking.

Similarly, Hernández et al. (2017) have investigated research activity as it takes place in learning communities based on ICT. These communities aim to disseminate and exchange knowledge between members through technology-based functions. By investigating through Scopus, the researchers collected 226 publications. With regards to the number of publications per year, it was observed that this rate peaked in 2010, whereby a slight decrease followed. The main

conclusion was that ICT assists learning communities. However, their function needs to focus on four fundamental principles: access, creation, collection and connection of materials. It is additionally established that cooperation between community members was a basic condition for an efficient outcome.

Chen et al. (2019) investigated research topics, authors' profiles and collaboration networks based on 3963 articles retrieved from the Web of Science, published between 1978-2018, in *Computers & Education*. The researchers conclude that there has been an increase in the number of articles, especially after the first decade of 2000. Collaborations are also increasing, especially between authors of the same institution or the same country. The most frequent keywords occurring in the articles were "interactive learning environment", "teaching/learning strategies", "pedagogical issue" and "computer assisted communication".

Tibaná-Herrera et al. (2018) have investigated publications regarding e-learning in 3680 articles from 219 journals, published between 2012 and 2014, as collected through Scopus. E-learning was found to be linked to different issues that the researchers describe as "descriptors". These can be modes of learning such as online, social, lifelong, or virtual learning. It was also linked to applications such as simulations, augmented reality, MOOCS, and education technology. Lastly, it was linked to instructional issues such as learning objects, instructional design, learning environment, teaching and learning, and learning analytics. Küçük-Avci et al. (2022) investigated 746 articles on online learning published between December 2019 and January 2020, right before the outbreak of the Covid-19 pandemic. They concluded that the most frequent keywords were "higher education", "e-learning", "blended learning" and "distance education". This demonstrates the application these types of online learning have in higher education institutions.

In addition, there is significant bibliometric research on implementing online learning during the Covid-19 pandemic after the year 2020. Baber et al. (2022) carried out a bibliometric study of publications on digital literacy. They examined 2307 articles published between 2017 and 2021. The main findings were that the rate of publications around digital literacy has risen during these years. Digital literacy is associated with concepts such as fake news, education, competency and Covid-19. In a bibliometric study, Karakose and Demirkol (2021) aimed to explore the impact of Covid-19 on research trends. In doing so, they investigated 8324 articles published during the year 2020. They concluded that topics such as online learning, distance education, blended learning, and teacher education came in greater frequency than others. Most of the publications disseminated research on data deriving from content analysis, descriptive statistics, correlation or interviews. The samples were usually students, teachers, university teachers, and academics.

Lastly, they also concluded that the field of health concerned a comparatively larger number of these publications.

Zhang et al. (2022) provided a holistic view of research on online learning during the Covid-19 lockdown period. Through research on 1061 articles, they conclude that online learning has been implemented and researched in the context of higher education, by a rising number of authors and research groups, in many countries around the world. Challenges were mentioned in the articles, such as infrastructure, teacher training, student preparation, and mental health issues. Similar was the bibliometric research by Çiçek Korkmaz and Altuntaş (2022), who examined 1280 articles published on nursing and health education. They concluded that there is a rising interest in researching that area of study, especially as concerns topics such as students, online learning and the effect of the pandemic. The countries with the largest number of publications were the United States, China, Spain, Australia, Brazil, Turkey, and England.

There were research projects examining specific fields of study. Karakose et al. (2021) investigated the effects that Covid-19 had on medical education at the global level. By analyzing 446 articles, they concluded that the countries with the greatest number of publications were the United States, the United Kingdom, China, Singapore, and Canada. Among the most frequent keywords were "telemedicine", "online teaching", and "e-learning", which proves that these concepts have grabbed the interest of researchers in the field. Metinal and Gumusburun Ayalp (2022) conducted a bibliometric analysis regarding articles about architectural education during Covid-19. They concluded that there was a focus on online learning and distance education. Topics that have risen are the students' experience with online learning, transition and adaptation, blended learning implementation, and curriculum and development, along with other trends about re-organization and integration.

The main conclusion is that the previous bibliometric studies before the Covid-19 pandemic have investigated the research trends around the publications of education technologies before 2020. These focused on different aspects and contexts of using technologies in learning. The common conclusions were perhaps the rising number of publications and the variety of keywords around education learning, which reflect probably the complexity of this topic, along with its necessity (Hernández et al., 2017; Rodríguez Jiménez et al., 2019; Tibaná-Herrera et al., 2018; Chen et al., 2019). On the other hand, the bibliometric studies around online learning during the Covid-19 lockdown period are significant in number. A common conclusion is that there is interest in what concerns online learning and its application (Baber et al., 2022; Zhang et al., 2022). Aside from that, some fields, such as health studies, seem to prevail (Karakose & Demirkol, 2021; Karakose et al., 2021).

Materials and Methods

The bibliometric data on online learning in higher education was retrieved on 1 January 2023 from Scopus, a world-leading bibliographic database of peer-reviewed literature. The Scopus database was preferred because it has a broader coverage of scientific research than other databases such as Web of Science (Falagas et al., 2008). This was further confirmed with the initial search using the same search query in both databases, revealing that Scopus provided more relevant documents than Web of Science. Moreover, compared to the Scopus database, the Web of Science significantly underrepresents scientific disciplines of the Social Sciences and Arts and Humanities (Mongeon & Paul-Hus, 2016). Therefore, Scopus appears to be a more relevant bibliographic database meeting the specifics of this research.

The search query covered keywords related to different online learning types. To compare the research on online learning in higher education, the search was conducted separately for the period before (2017-2019) and during (2020-2022) the Covid-19 pandemic. The search for the second period was additionally limited using "covid" as a keyword, isolating Covid-19-related research from other general research on online learning. Finally, the obtained collection of documents on online learning research was narrowed to documents related only to higher education, thereby excluding documents related to primary, secondary, and adult education. The bibliometric analysis utilized several bibliometric approaches, performed using the Python Data Analysis Library Pandas (McKinney, 2012).

Results

The search strategy for online learning research yielded 13139 documents, of which 6994 were published before and 6145 were published during the Covid-19 pandemic. The most relevant, highly cited documents in online learning research before and during the Covid-19 pandemic are presented in Tables 1 and 2. Before the Covid-19 pandemic, online learning research was predominantly focused on exploring the potential of virtual learning, including augmented/virtual reality, in the context of higher education (Jensen & Konradsen, 2018; Makransky et al., 2019; Ibáñez & Delgado-Kloos, 2018; Martín-Gutiérrez et al., 2017), with some attempts to appropriately adapt the distance learning process for some specific courses (Elgrishi et al., 2018). Recently, online learning research shifted towards exploring pedagogy (Bao, 2020; Rapanta et al., 2020; Pokhrel & Chettri et al., 2021), life and work (Aristovnik et al., 2020) and higher education delivery (Mishra et al., 2020).

Table 1

Most Relevant Documents before the Covid-19 Pandemic

Authors	Year	Title	Source title	Cited by	Online learning	Country
Elgrishi et al.	2018	A practical beginner's guide to cyclic voltammetry	Journal of Chemical Education	1463	Distance learning	US
Jensen & Konradsen	2018	A review of the use of virtual reality head-mounted displays in education and training	Education and Information Technologies	489	Virtual learning	Denmark
Makransky et al.	2019	Adding immersive virtual reality to a science lab simulation causes more presence but less learning	Learning and Instruction	460	Virtual learning	Denmark
Ibáñez & Delgado-Kloos	2018	Augmented reality for stem learning: A systematic review	Computers and Education	376	Virtual learning	Spain
Martín-Gutiérrez et al.	2017	Virtual technologies trends in education	Eurasia Journal of Mathematics, Science and Technology Education	358	Virtual learning	Spain

Note. Top cited documents in online learning research before the Covid-19 pandemic.

Source: Authors' elaboration based on the Scopus database.

Table 2

Most Relevant Documents during the Covid-19 Pandemic

Authors	Year	Title	Source title	Cited by	Online learning	Country
Bao	2020	Covid-19 and online teaching in higher education: A case study of Peking university	Human Behavior and Emerging Technologies	954	e-learning	China
Rapanta et al.	2020	Online university teaching during and after the Covid-19 crisis: Refocusing teacher presence and learning activity	Postdigital Science and Education	716	e-learning	Portugal
Aristovnik et al.	2020	Impacts of the Covid-19 pandemic on life of higher education students: A global perspective	Sustainability (Switzerland)	682	e-learning	Slovenia
Mishra et al.	2020	Online teaching-learning in higher education during lockdown period of Covid-19 pandemic	International Journal of Educational Research Open	637	e-learning	India
Pokhrel et al.	2021	A literature review on impact of Covid-19 pandemic on teaching and learning	Higher Education for the Future	561	e-learning	Bhutan

Note. Top cited documents in online learning research before the Covid-19 pandemic.

Source: Authors' elaboration based on the Scopus database.

The most productive and characteristic countries for each period, i.e. before and during the Covid-19 pandemic, as well as countries which cannot be statistically classified (Yule Q) into one of these two groups (neutral), are presented in Table 3. It is evident that large and developed countries were more involved in online learning research before the Covid-19 pandemic (with some equally engaged in both periods) while emerging and predominantly large Muslim countries increased

their research activity during the Covid-19 pandemic. This implies that in large and developed countries, online learning was already well-established before the Covid-19 pandemic and has been only further expanded to accommodate increased demand. In contrast, numerous emerging and large Muslim countries have faced greater challenges (e.g., poor internet connection, insufficient knowledge about the use of ICT, etc.) in transitioning to online learning, leading to higher interest in the research during the Covid-19 pandemic (Maatuk et al., 2022).

Table 3

Characteristic Countries before and during the Covid-19 Pandemic

Before	Neutral	During
Australia	China	Saudi Arabia
United Kingdom	Canada	Indonesia
Spain	Hong Kong	India
Russian Federation	Portugal	Turkey
United States	France	Malaysia

Note. Countries in the before and during group are sorted by Yule Q, while countries in the neutral group are sorted by the number of documents.

Source: Authors' elaboration based on the Scopus database.

A similar classification of most productive and characteristic sources, i.e., scientific journals, is presented in Table 4. It reveals a significant shift towards publishing online learning research in open-access journals, as observed by some of the previous bibliometric studies of online learning during the Covid-19 pandemic (Zhang et al., 2022).

Table 4

Characteristic Sources before and during the Covid-19 Pandemic

Before	Neutral	During
Turk. Online J. Distance Educ.	Educ. Inf. Technol.	Int. J. Environ. Res. Public Health
Online Learn. J.	J Chem Educ	Front. Educ.
Br J Educ Technol	Interact. Learn. Environ.	Front. Psychol.
IEEE Access	Int. J. Interact. Mob. Technol.	Sustainability
Int. J. Emerg. Technol. Learn.	Electron. J. e-Learning	Educ. Sci.

Note. Sources in the before and during group are sorted by Yule Q, while sources in the neutral group are sorted by the number of documents.

Source: Authors' elaboration based on the Scopus database.

Based on the extensive examination of keywords in the obtained collection of documents, three main pillars of online learning research were identified, namely: 1) ICT tools, including five different tools, which can be used in the context of online learning; 2) online learning approaches, covering six possible approaches to provide higher education; and 3) fields of study, including five main fields emphasized in the analyzed collection of documents. These pillars and

corresponding keywords are included in the analysis presented in Table 5 to determine characteristic ICT tools, online learning approaches, and fields of study before and during the Covid-19 pandemic.

Table 5

Characteristic Keywords before and during the Covid-19 Pandemic

ICT tools	Yule Q	Online learning approaches	Yule Q	Field of study	Yule Q
video conference	**0.758**	distance learning	**0.376**	medical education	**0.363**
social media	**-0.135**	virtual learning	**0.274**	mathematics education	0.112
augmented/virtual reality	**-0.404**	e-learning	**0.154**	social work education	0.012
learning management system	**-0.417**	blended learning	**-0.243**	nursing education	-0.072
mobile application	**-0.575**	computer/web-based learning	**-0.580**	engineering education	**-0.177**
		mobile learning	**-0.654**		

Note. Positive (negative) Yule Q coefficient indicates that a keyword is more characteristic for the period during (before) the Covid-19 pandemic. The bold number indicates a statistically significant coefficient ($p < 0.1$).

Source: Authors' elaboration based on the Scopus database.

Looking first at the ICT tools, the results suggest that video conferences are discussed in online learning research, especially during the Covid-19 pandemic, while the remaining tools seem to be highlighted in the research before the Covid-19-pandemic. As regards online learning approaches during the Covid-19 pandemic, most attention was devoted to exploring distance learning (pre-recorded online lectures), followed by virtual learning (real-time online lectures) and e-learning (a combination of asynchronous and synchronous learning). Since all these online learning approaches limit physical contact between teachers and students, they have been referred to as emergency remote learning approaches (Fuchs, 2022), while the remaining approaches (mobile learning, computer/web-based learning, and blended learning) do not necessarily take place in an online learning environment. Finally, medical education seems to be highlighted during the Covid-19 pandemic, while engineering education before it, as suggested by a significantly lower number of documents published in this period, implying not necessarily the irrelevance of engineering education in the post-Covid-19 era.

Finally, the results of binary regression analysis, in which some relevant keywords are regressed against the main ICT tools, are presented in Table 6. They suggest that academic success factors, such as student engagement and professional development, were more important before the Covid-19 pandemic, particularly in the context of video conferences, while mobile applications were more related to (student) self-efficacy and attitude. On the other hand, technology factors, such as artificial intelligence and technology acceptance, were relevant both before and after the Covid-19 pandemic, especially in the context of learning management

systems. Additionally, pedagogy issues emerged as significant factors in augmented/virtual reality and learning management systems during the Covid-19 pandemic, as well as in the context of mobile applications in both periods. As expected, public and mental health issues were more widely discussed in online learning research during the Covid-19 pandemic, especially in relation to social media. Finally, medical (and also nursing) education received greater attention during the Covid-19 pandemic in the context of video conferences, whereas less focus was given to these fields of study in the context of learning management systems. Finally, engineering education is related to augmented/virtual reality before the Covid-19 pandemic and learning management systems during the Covid-19 pandemic.

Table 6

Results of Binary Logistic Regression

	video conference		social media		augmented/ virtual reality		learning management system		mobile application	
	before	during	before	during	before	during	before	during	before	during
Academic success										
academic performance				1.069						
student engagement	2.110		0.876							
self-efficacy									1.706	
attitude									1.501	
professional development	2.274									
Technology										
artificial intelligence							0.699	0.969		
digital divide			1.703							
technology acceptance							1.074	1.611		
Pedagogy										
evaluation							1.014			1.910
pedagogy						1.275				
teaching methods									2.671	
Public and mental health										
public health				1.380						
anxiety					1.620					
depression				2.543						
Fields of study										
medical education		0.731					-2.124	-1.607		
nursing education		1.182					-1.684		1.394	
engineering education					1.568			1.236		

Note. The binary logistic model is performed on 30 predictors, whereby each cluster was tested separately. Only statistically significant coefficients (p < 0.1) are presented. A positive (negative) coefficient indicates that a document with a selected keyword is likely (unlikely) to be related to a certain ICT tool.

Source: Authors' elaboration based on the Scopus database.

Conclusion

The present bibliometric study provides several important insights from online learning research before and during the Covid-19 pandemic. The results reveal that the most recent top-cited documents focused on pedagogy, life and work, and higher education delivery. Moreover, the results show that large and developed

countries were already well-established in online learning research before the pandemic, while emerging and predominantly large Muslim countries increased their research activity during the pandemic. This suggests that former countries were better equipped to handle the transition to online learning, while the latter faced challenges, resulting in a higher interest in research during the pandemic (Maatuk et al., 2022). The results further reveal a significant shift towards publishing online learning research in open-access journals, which is also observed by some of the previous bibliometric studies of online learning during the Covid-19 pandemic (Zhang et al., 2022). Furthermore, the results also reveal that online learning research was recently discussed in the context of so-called emergency remote learning (Fuchs, 2022), as suggested by distance learning, virtual learning, and e-learning aiming to limit physical contact between teachers and students, being the most characteristic online learning approaches after the Covid-19 pandemic. Finally, regression analysis reveals the most important factors predicting selected ICT tools.

Before generalizing these conclusions, it is important to point out the limitations of the paper. First, the bibliometric analysis relies on documents indexed in the Scopus database, which might not cover the entire collection of the research. Therefore, utilizing other databases like the Web of Science may have disclosed some further insights not revealed by this paper. Second, despite the detailed search query, some other relevant keywords might not be considered in the document search. Finally, as a methodological approach based on big data analysis, the bibliometric method may miss certain highlights from the scientific literature that a systematic literature review would otherwise capture. Regardless of these limitations, the findings may benefit the scientific community in facilitating the detection of research gaps in online learning research during the Covid-19 pandemic and evidence-based policymaking to help identify appropriate educational practices in emergencies.

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Author Details

Aleksander Aristovnik
University of Ljubljana, Faculty of Public Administration
Slovenia
aleksander.aristovnik@fu.uni-lj.si

Lan Umek
University of Ljubljana, Faculty of Public Administration
Slovenia
lan.umek@fu.uni-lj.si

Dejan Ravšelj
University of Ljubljana, Faculty of Public Administration
Slovenia
dejan.ravselj@fu.uni-lj.si

Konstantinos Karampelas
University of the Aegean, Department of Primary Level Education
Greece
kkarampelas@aegean.gr