Tendencias en la producción científica en e-learning antes y después del Covid-19: Un estudio bibliométrico basado en Scopus

Trends in scientific output in E-learning before and after Covid-19: A bibliometric study based on Scopus

Gerardo Tibana-Herrera
Universidad de los Andes\ Gerardo.tibana@scimago.es\ https://orcid.org/0000-0003-2056-7605
SCImago Research Group, Colombia

Hector Santillan Faulkner
Universidad de Lleida\ hsantillan@unphu.edu.do \ https//orcid.org/0000-0002-1075-7061
Universidad Nacional Pedro Henríquez Ureña, Republica Dominicana

RESUMEN

La educación virtual (e-learning), afronto durante la pandemia del COVID-19 su más grande reto para responder a las inquietudes que durante años se han formulado sobre su utilidad, eficiencia y resulta- dos frente al aprendizaje. Este estudio se basó en el análisis bibliométrico para comparar el aporte al conocimiento en e-learning desde la producción científica. Para la comparación, se extrajeron los datos bibliográficos de los documentos publicados en la base de datos Scopus, durante los periodos 2018-2019 y 2020-21. Entre los resultados, la comparación mostro el crecimiento en el volumen de la producción científica, en particular por los artículos de conferencia publicados en revistas relacionadas con *Computer Science*, también introduce a Indonesia como actor relevante durante el último periodo, sumándose al impulso que Asia le ha brindado a esta temática en los últimos anos. Como conclusión, durante la pandemia, la investigación en e-learning se orientó a fortalecer temas como la salud mental de los estudiantes, el diseño centrado en el usuario y la usabilidad de sus contenidos y plataformas. Sera necesario un análisis posterior para analizar la continuidad de las estrategias en el escenario postpandemia.

Palabras clave: bibliometría, análisis de coocurrencia, impacto de la pandemia, COVID-19, e-learning, usabilidad, diseño centrado en el usuario

ABSTRACT

Virtual education (e-learning) faced its greatest challenge during the COVID-19 pandemic, to respond to the concerns that have been raised for years about its usefulness, efficiency and learning results. This

study was based on bibliometric analysis to compare the contribution to knowledge in e-learning from scientific production. For comparison, bibliographic data was extracted from the documents published in the Scopus database, during the 2018-2019 and 2020-21 periods. Among the results, the comparison showed the growth in the volume of scientific production, by conference papers published in journals related to Computer Science, also introduces Indonesia as a relevant actor during the last period, adding to the momentum that Asia gave it. has provided to this subject in recent years. In conclusion, during the pandemic, research in e-learning was oriented towards strengthening issues such as the mental health of students, user-centered design and the usability of its content and platforms, a subsequent analysis will be necessary to analyze the continuity of strategies in the post-pandemic scenario.

Keywords: Bibliometrics, co-occurrence analysis, impact of the pandemic, COVID-19, e-learning, usability, user-centered design

Introduction

Teaching comprises very interesting processes that, wh the world, the Internet, become more complex (e-Lea monitored to ensure continuous improvement, inclu communication, value delivered to participants (*Eslav* When it comes to the technical side of e-Learning, org resources to support distance learning in psychosocial learning, self-managed learning, accompanied learnin 2018). The use of these resources had a significant cha more flexible strategies (*Amin Almaiah et al.*, 2020). (*Bhuasiri et al., 2012*), objective assessment of lear facilitators' approaches, and preparation and support fo *al.,* n.d.), as it would be a mistake to assume that they improve their teaching practices.

During the COVID-19 pandemic, the adequ technologies, the accessibility of synchronous a videoconferencing tools and Learning Management Sys urgent needs to continue with the training processes at of this study is to identify and highlight the main chan of information the bibliometric analysis of the scientif previous studies (*Shih et al.,* 2008) (*Aparicio et al.,* 20

The bibliometric analysis of the documents was correlation of variables (in this case metadata), thema terms) and word clouds (trends).

The tools used in the last two techniques were *V* The combination of visualization techniques allows h publication and connection between analysis units (var

Method

The Scopus database was used for this study due to its metadata quality and annual growth of indexed journals (*Leydesdorff et al.*, 2009). Using the advanced search function, a query was configured, omitting the possible inclusion of terms related to the subject "Machine Learning" that could bias the results. The query can be consulted in Annex 1.

The query was divided into two time periods, to be able to perform trend comparison actions, the first group is made up by the documents published between 2018 and 2019 and the second group the documents published between 2020 and 2021, the main years of the pandemic.

Only documents related to primary scientific production (review articles and conference articles) were considered, as they are considered as the scientific production validated by third parties that mainly responds to research projects carried out by institutions and governments (Romo-Fernandez et al., 2013).

The following units of analysis were defined during the study:

- Total production. Number of documents published in scientific journals indexed in Scopus that respond to the constructed query.
- Type of document. Typology through which authors communicate their research results.
- Area of knowledge. Thematic classification of the journals in which the results are communicated, allowing the identification of adjacent knowledge structures (*Blázquez-Ruiz et*

Results

The consultation showed a total of 23178, divided into each group as follows: Group 1 with 9,459 documents and Group 2 with 13,719. Figure 1 shows the evolution of documents published during the period analyzed.

Figure 1. Evolution of scientific production on e-learning.
Source: Scopus
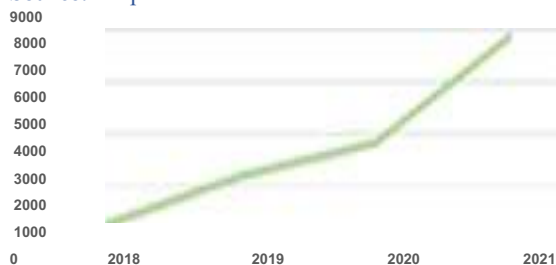
Two primary results can be clearly observed; the first, that the scientific production of the second period is higher than the first by 4,260 documents, equivalent to 18.3% of the total production; the second, is that the scientific production on E-learning has grown by 45.9% in the period analyzed, reversing the findings of *Tibana-Herrera*, which showed a decline in production since 2013 (*Tibana-Herrera et al.,* 2018b).

**Analysis per type of document**

The total scientific output is communicated through the types of primary communication, these show that, during the period of analysis, there is greater interest in the publication of conference articles, in response to the fact that it is the type of communication par excellence for researchers related to Computer Science, followed by research articles, and finally review articles.

Figure 2 shows the total distribution and the distribution in each of the periods. It is observed how, in the second period, the distribution changes in favor of the publication of research and review articles, with a growth of 87% and 234%, respectively.

Analysis per area of knowledge

Areas of knowledge are identified according to the selected communication channel for the dissemination of the document, these are associated with the journals in the Scopus database and thus it is possible to perform this analysis. Figure 3 shows, in comparative terms, the total production in E-learning associated to the 10 main areas of knowledge, revealing that the triad Computer Science, Social Sciences, and Engineering groups most of the production in the head of the Computer Science area, again, showing changes in the pattern of the production trend compared to previous findings.

Figure 2: Distribution of E-learning output by document type
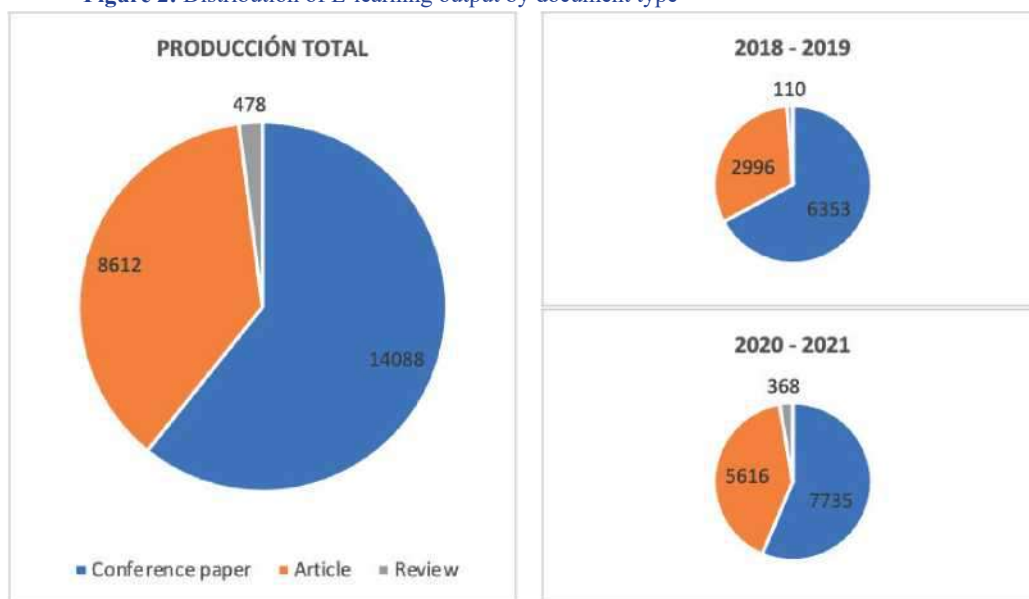
Fuente: Scopus

The figure also shows, in parallel columns, the percentage of output for each period analyzed. This visualization makes it possible to recognize the changes in the contribution of each area to the generation of knowledge in E-learning. Medicine had the highest growth from one period to another, going from position 7 to 4, followed by Energy, which went from position 10 to 8.

**Figure 3.** Comparison of the ratio of areas in the generation of knowledge in E-learning

%(2018-2019)   ^^%(2020-2021)   2018-2019   2020-2021
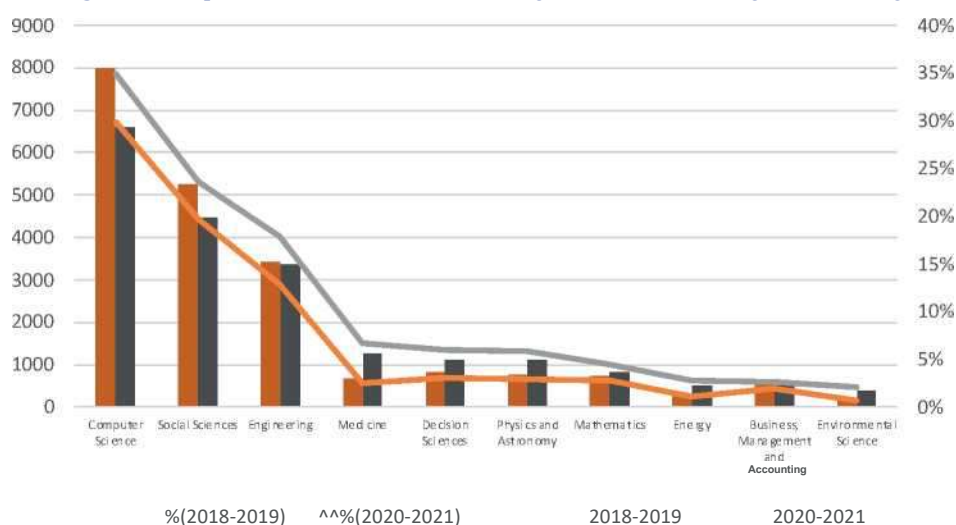
Source: In-house development

Knowledge Structure

Through the technique of co-authorship-based network analysis, the knowledge structure underlying the papers and journals can be discovered. These networks show how the central knowledge area is Social Sciences and from this area relationships are deployed to other areas, mainly *Computer Science and Engineering*, reinforcing the findings of the previous analyses. Figure 4 shows the structure of knowledge compared in the time periods, only the change between the relationships, *Economics, Econometrics, and Finance directly with Business, Management and Accounting* and the absence of production in Material Sciences in the last period is evident.

Figure 4. Knowledge structure of E-learning output. Comparison between the periods comprising 2018.2019 y 2020.2021
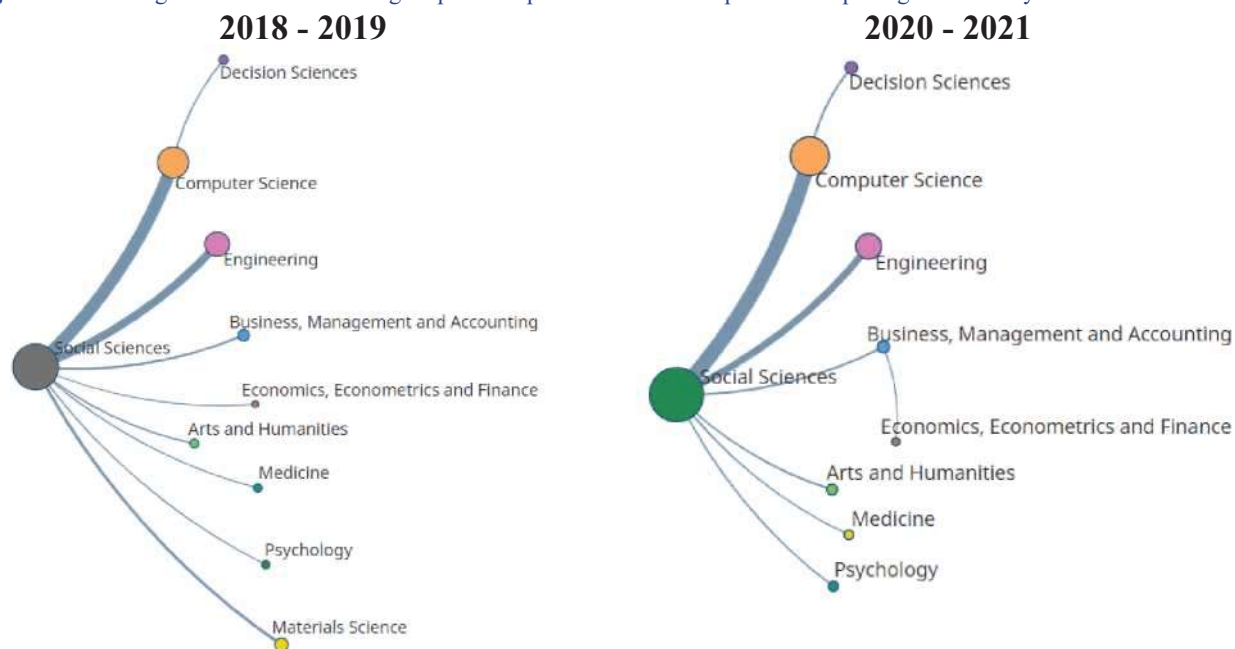
Fuente: In-house development

Main E-learning knowledge-producing countries

The co-authorship analysis technique, together with the metadata associated with institutional affiliation, makes it possible to extract the relationships between countries, resulting from international collaborative work and bilateral projects established between governments (*Hoekman et al.,* 2010). Using the VosViewer tool, a knowledge map is generated that allows these relationships to be viewed and the volume of production to be associated with the size of the nodes.

Figure 5 highlights 4 clusters, the first with China and the United States leading in production, although China has more collaboration than the United States (435 and 336 respectively), it is the United States that collaborates with the largest number of different countries. The second cluster presents Indonesia as a central player in production and collaboration with different countries. The third cluster shows a strong relationship between Spain, the United Kingdom, and Germany. The last cluster with countries from Asia and the Middle East has a smaller but at the same time more balanced production. There is a last cluster, not very representative in the visualization, formed by the production and collaboration between Colombia and Argentina.

**Figura 5.** Country-Level Co-authorship Network
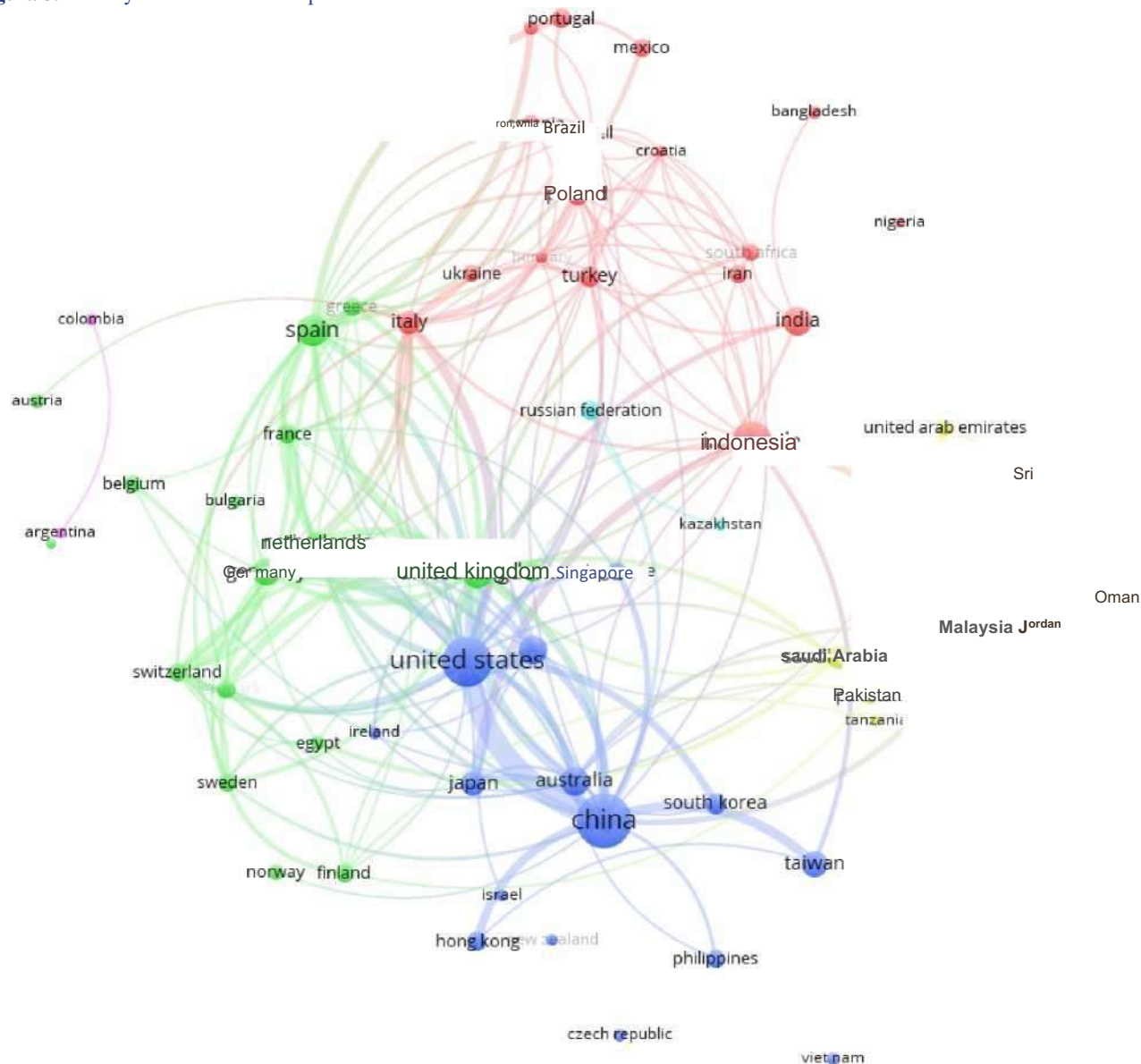
Main topics investigated in the periods of analysis

By associating the cooccurrence analysis technique with the keywords metadata of the published documents and with the date of publication of the documents, a knowledge map can be generated that reveals the publication themes over time. Figures 6 and 7 show these maps for each of the periods analyzed.

2018 - 2019. In this period the research topics started around E-learning in higher education is developed, on online learning and mobile learning modalities. At the end of the period, issues related to the concept of online education, ontologies, and self-regulated learning as a necessary and essential condition for the development of any e-learning project are presented.

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Figure 6. Knowledge map on the thematic evolution in E-learning 2018-2019
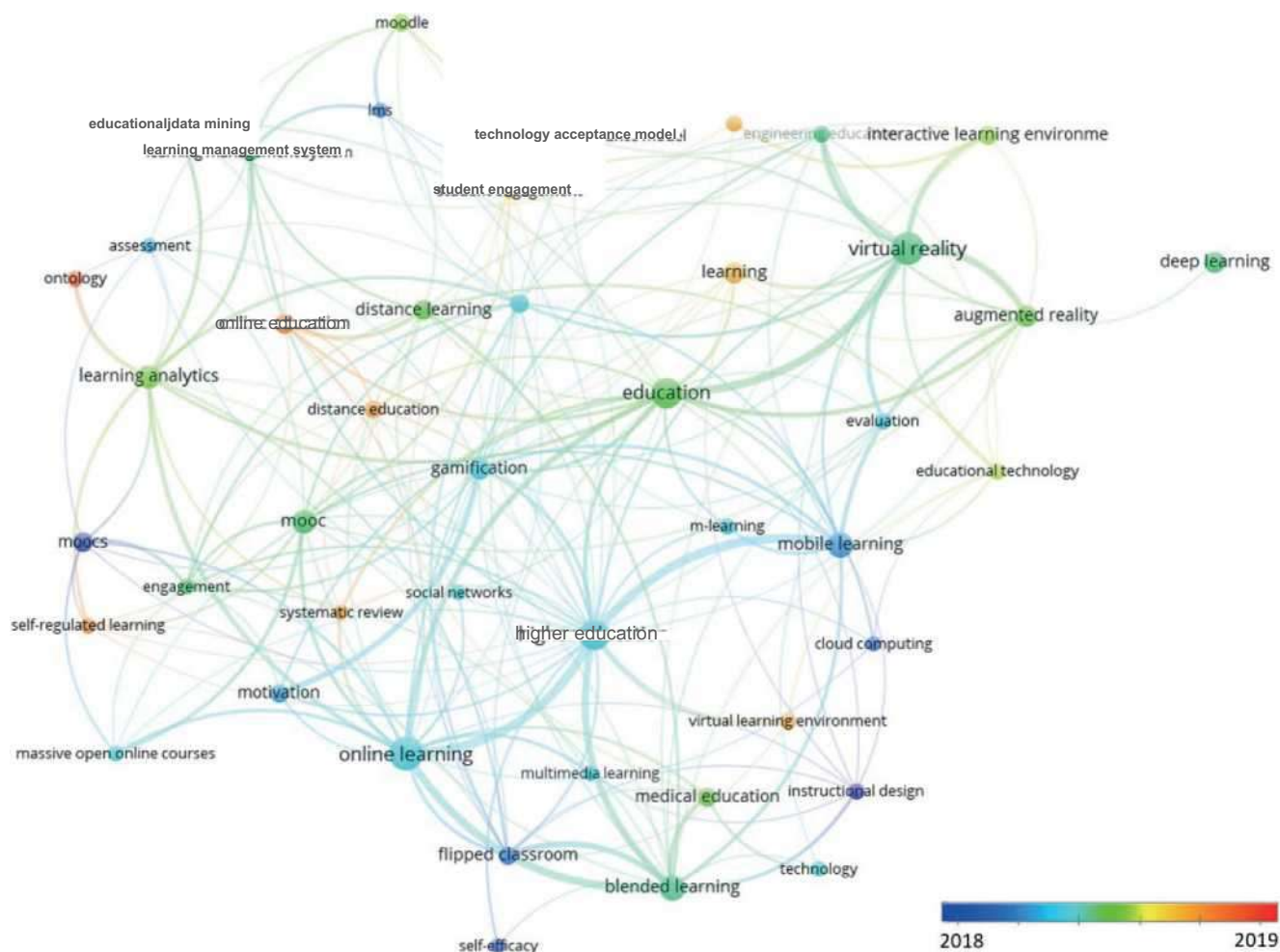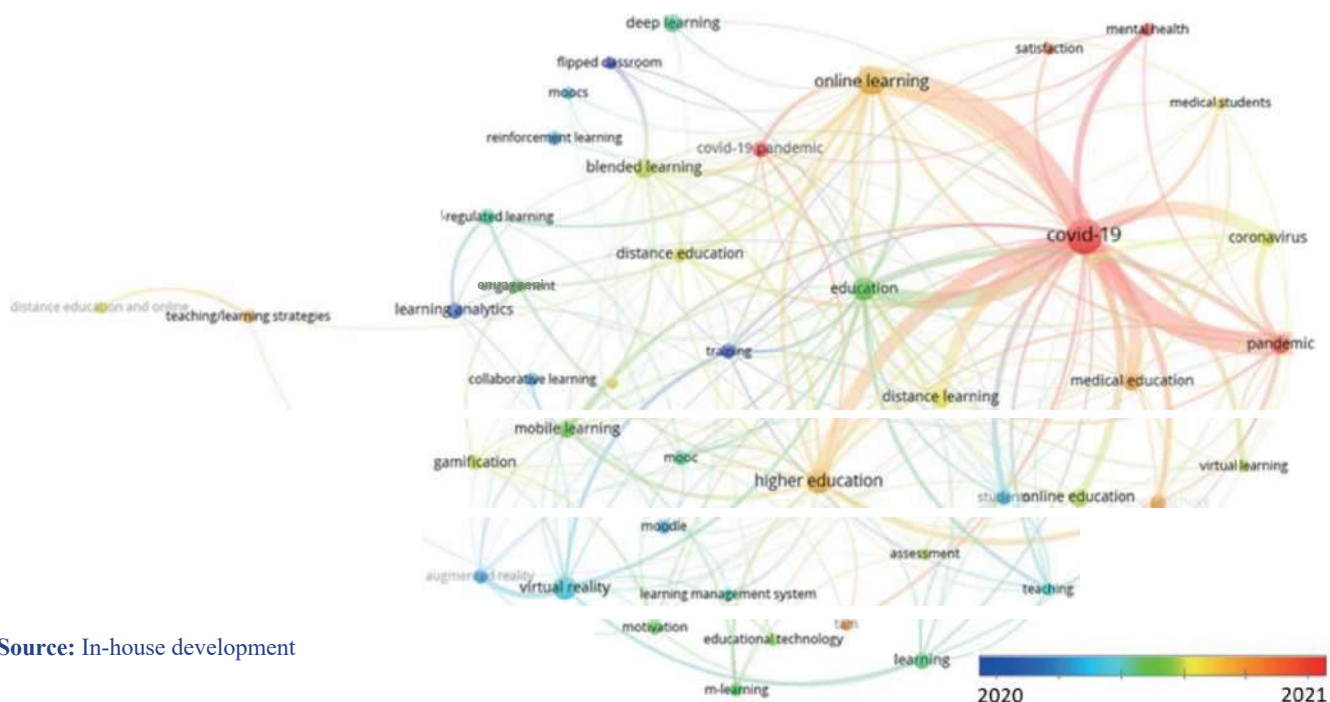

Source: In-house development

2020 - 2021. The period begins with very specific topics related to other trends such as learning analytics, virtual reality, and augmented reality. It also shows the relationships between teacher training and learning modalities. This map shows at the end of the period the strong trend in analyzing COVID-19, the effects of the pandemic and the mental health component of the pandemic.

The strong trend is seen in the volume of network links that relate COVID-19 to higher education, online learning, medical education, and education in general. This demonstrates the sensitivity of the e-learning research community to using the tools, techniques, and methodologies to address the challenges presented by the pandemic.

Figure 7. Knowledge map on thematic evolution in E-learning 2020-2021

Source: In-house development

Main topics in scientific output

The Scopus Topic prominence tool displays triads of research topics from the authors' point of view. These triads group a set of documents on which keyword cloud visualizations can be performed (Figures 8 and 9). The size of the words indicates whether the topics have become more relevant or are in decline, the color indicates the evolution over the period, from blue to green. This is a very useful tool for mapping scientific yield (Santos et al., n.d.). In this study, two triads related to the e-learning theme were identified, these were:

E-Learning; Electronic Learning; Usability; (T.48060). In this triad, the terms related to user experience and usability in virtual environments, as well as the user-centered design of educational and pedagogical experiences, are relevant.

Figure 8. Keywords cloud of the triad: E-Learning; Electronic Learning; Usability.

Online courses; MOOC; Blended learning; (T.6479).

In this triad most of the terms have been presented at the end of the period, highlighting the relevance of E-learning, MOOCs as a learning alternative during the pandemic through the distance education modality. also highlights the interest in learning analytics and computer-supported education.

Source: In-house development

The analysis shows a high level of collaboration between institutions, placing new players on the world stage, as is the case of Indonesia, whose scientific production and collaboration place it at the forefront in Asia and the Middle East, only behind China.

The publication themes have been aligned in interaction with other emerging disciplines such as usability and user experience, which during the pandemic played a key role in student retention and learning effectiveness.

Finally, it can be said with certainty that in the wake of the COVID-19 pandemic, the global society turned to the educational system to find a way to continue with the teaching and learning processes, and it was E-learning, its techniques and strategies that most educational institutions responded. Future studies should analyze the consequences of this "forced" use of E-learning during the pandemic for the discipline and its evolution.

Conclusions

The scientific output in E-learning has had a significant increase during the period of the COVID-19 pandemic, growing by 18.3% compared to the immediately preceding period (2018-2019). This growth is mainly due to the role played by Conferences for the dissemination of knowledge, with topics related to Computer Science, as is the case of E-learning.

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Annex 1.
TITLE-ABS-KEY ("e-learning") AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT- TO (PUBYEAR , 2018)) AND (LIMIT-TO (LANGUAGE , "English")) AND (EXCLUDE (EXACTKEYWORD , "Machine Learning") OR EXCLUDE (EXACTKEYWORD , "Learning Algorithms") OR EXCLUDE (EXACTKEYWORD , "Artificial Intelligence") OR EXCLUDE (EXACTKEYWORD , "Personnel Training") OR EXCLUDE (EXACTKEYWORD , "Neural Networks") OR EXCLUDE (EXACTKEYWORD , "Classification (of Information)") OR EXCLUDE (EXACTKEYWORD , "Big Data")

OR EXCLUDE (EXACTKEYWORD , "Application Programs") OR EXCLUDE (EXACTKEYWORD , "Deep Neural Networks") OR EXCLUDE (EXACTKEYWORD , "Decision Trees") OR EXCLUDE (EXACTKEYWORD , "Convolutional Neural Networks") OR EXCLUDE (EXACTKEYWORD , "Support Vector Machines") OR EXCLUDE (EXACTKEYWORD , "Convolutional Neural Network") OR EXCLUDE (EXACTKEYWORD , "Computer Programming") OR EXCLUDE (EXACTKEYWORD , "Automation") OR EXCLUDE (EXACTKEYWORD , "Stochastic Systems") OR EXCLUDE (EXACTKEYWORD , "Regression Analysis") OR EXCLUDE (EXACTKEYWORD , "Image Processing") OR EXCLUDE (EXACTKEYWORD , "Iterative Methods"

Gerardo Tibana

BSc. in Systems and Computer Engineering from Universidad de los Andes, with a Master's degree in Computer Engineering from the same university, and a PhD in Documentation Sciences from Universidad Complutense of Madrid. His studies have focused on Information and Communication Technologies -ICT- and virtual education (E-learning) to facilitate the development of teaching and learning methodologies. Recently, he was responsible for the project "Editor's Curriculum" at the Ministry of Science, Technology, and Innovation of Colombia, which has allowed the basic and advanced training of over 500 editors of Colombian scientific journals, in hybrid, synchronous and asynchronous modalities.

Hector Santillán Faulkner

BSc. in Computer Science, Information Technology and Communication from UNIBE University, with 10 years of experience in the IT area. Master's in Cybersecurity with a double major from the University of Lleida and NEXT IBS. He has worked in Real Estate, IT services, Business Security and Auditing. He is currently working as IT Risk and Compliance leader in the private sector, and as Director of the School of Computer Science at UNPHU.