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Digital competences, use of ICT and innovative and emerging technologies in higher education. A bibliometric analysis

Competencias digitales, uso de las TIC y tecnologías innovadoras y emergentes en la enseñanza superior. Un análisis bibliométrico

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ABSTRACT. In recent decades, the advance of digitalization has impacted virtually all sectors of society, including the educational environment. Consequently, the learning and teaching process has changed due to innovations, technology and emerging ICT tools. The aim is to analyze the current state and evolution of scientific research on digital innovations in higher education. Using VOSviewer software, 697 and 755 articles published in the Web of Science and Scopus databases, respectively, between 2014 and 2023 were analyzed. The results support that the role of digital competences is having a progressive growth in the scientific literature, reaching the highest registration of articles in 2019. In conclusion, it is considered that innovation in all its aspects is a key factor in education and, therefore, it is necessary to continue researching this topic.

RESUMEN. En las últimas décadas, el avance de la digitalización ha impactado en prácticamente todos los sectores de la sociedad, incluyendo el entorno educativo. Consecuentemente, el proceso de aprendizaje y enseñanza ha cambiado debido a las innovaciones, la tecnología y las herramientas TIC emergentes. El objetivo es analizar el estado actual y la evolución de la investigación científica sobre las innovaciones digitales en la educación superior. Mediante el software VOSviewer, se analizaron 697 y 755 artículos publicados en las bases de datos de la Web of Science y Scopus, respectivamente, entre los años 2014 y 2023. Los resultados avalan que el papel de las competencias digitales está teniendo un progresivo crecimiento en la literatura científica, alcanzando el mayor registro de artículos en 2019. Como conclusión, se considera que la innovación en todas sus vertientes es un factor clave en la educación y, por ello, es necesario continuar investigando sobre esta temática.

KEYWORDS: Higher education, Competences, Skills, Digital, Technology.

PALABRAS CLAVE: Enseñanza superior, Competencias, Aptitudes, Digital, Tecnología.

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1. Introduction

In recent decades, technological advances have had an impact on the educational context, causing educational institutions to search, develop and use new tools in accordance with the current reality (Alfaro-Ponce et al., 2023; Guillén-Yparrea et al., 2023; Pérez-Calderón et al., 2021). In this way, digital transformation has been defined as a process whose objective is to improve a certain area through significant changes, combining different information technologies, computing, connectivity and communication (Vial, 2021).

Thus, digitalization and the implementation of new technologies have had a transcendental impact on learning (Alfaro-Ponce et al., 2023; Tejedor et al., 2020). Specifically, we are facing the fourth industrial revolution, which is generating numerous opportunities for the development of science, innovation and knowledge (Alé-Ruiz et al., 2023; Arias-Abelaira et al., 2023; Ilori & Ajagunna, 2020). Furthermore, in recent years, an important event that took place in this scenario was the Covid-19 pandemic, which drove the digital transformation of higher education, causing a greater speed in the process of virtualization of teaching to meet the need for online education (Guillén-Yparrea et al., 2023; Tóth-Pajor et al., 2023). Consequently, it can be said that the pandemic represented a favorable and leveraging scenario for technological innovation in teaching (Tóth-Pajor et al., 2023).

In this paradigm, higher education is of great importance, as it offers educational responses to citizens and professionals in the face of current new challenges (Massaro, 2022; Moscardini et al., 2022). Therefore, this educational stage must focus on attractive, effective and efficient learning in which technological advances play a fundamental role (Alé-Ruiz et al., 2023; Goh et al., 2020; Singh & Miah, 2020). In this sense, there are various new methodologies and tools present in the educational process, such as education 4.0, game-based learning, videos, collaborative learning, mobile devices, smart boards, MOOC courses, dynamic visualizations, virtual laboratories, crowdsourcing, among others (Alfaro-Ponce et al., 2023; Almeida & Simoes, 2019; Blau et al., 2020; Guillén-Yparrea et al., 2023; López-Pernas et al., 2019; Murillo-Zamorano et al., 2020; Orús et al., 2016; Thompson, 2019).

Thus, the educational environment, teaching-learning methods and pedagogical approaches are undergoing a digital transformation to meet new needs and the digitalized future, with traditional educational methods being relegated to the background (Abysova et al., 2023; Alfaro-Ponce et al., 2023; Iivari et al., 2020). Therefore, previous literature shows that the combination of pedagogy, technology and educational content improves the learning process and achieves greater student motivation compared to the educational methods that have been traditionally used (Gonzalez et al., 2018; Murillo-Zamorano et al., 2020; Orús et al., 2016). In this scenario, it is essential that educational institutions adopt technological advances and include skills, digital competencies and teaching methodologies based on new technologies in their teaching processes to face the challenges of today's society (Alfaro-Ponce et al., 2023; Guillén-Yparrea et al., 2023).

The importance of digital skills in the educational environment is such that even different national, European and international organizations have highlighted their importance, emphasizing that they are a key resource for education systems today (Bond et al., 2018; European Commission, 2017; European Parliament, 2023; INTEF, 2022; OECD, 2023). In this line, it is worth highlighting that the Bologna directives within the European Higher Education Area (EHEA) focus on the acquisition of specific and transversal competences by the student, and among the referred transversal competences is the acquisition of skills to manage ICT (Orús et al., 2016; Pereira et al., 2014).

Previous research concludes that ICTs are a fundamental tool that facilitates active learning among students, motivates them, and improves results in terms of academic performance and acquisition of skills (Ferrer et al., 2011; Gonzalez et al., 2018; Huda et al., 2018; Huffman & Huffman, 2012; Krauskopf et al., 2012; Orús et al., 2016; Pereira et al., 2014; Schmid et al., 2014). Likewise, other research concludes that the proper use of educational innovations can cause positive impacts on student participation and learning, such as

teamwork, creative thinking, leadership, communication skills, or better interaction between teachers, students and content (Blau et al., 2020; López-Pernas et al., 2019; Murillo-Zamorano et al., 2020). However, certain authors point out the drawbacks of technological advances in the educational context, referring to aspects such as the commercialization of education, the increase in the amount of work or the relegation of critical thinking, causing a deterioration in the quality of higher education (Adell-Segura et al., 2018).

Furthermore, according to several studies, it is interesting to point out the relationship between higher education, as the final stage of learning, and its impact on the economic development of a country, highlighting the importance of the formation of human capital (Gennaioli et al., 2013; Kong et al., 2022; Shapiro, 2006). In addition to all of the above, some authors have pointed out that ICT skills and digital competences are increasingly in demand in the work environment, which highlights the need to include among the objectives of the higher education framework the preparation of new generations in this area for their future performance (Bond et al., 2018; Kruss et al., 2015; Orús et al., 2016). In this regard, previous studies determine that it is necessary for higher education institutions to instill certain skills that go beyond the specific knowledge of a subject to improve their employability in the current labor market, since globalization and technological development require highly trained employees and, ultimately, educational institutions must educate the young generation for the needs of the future (Iivari et al., 2020; Valencia-Arias et al., 2023). Likewise, numerous studies determine the need to take into account ICT training for teachers, since the insufficient digital literacy of teachers makes the technical-didactic use of these tools difficult (Hammond et al., 2009; Tejedor et al., 2020). As a result, the new challenge facing teachers involves changing traditional teaching methods towards digitalization (Abysova et al., 2023; Guillén-Yparrea et al., 2023).

This paper aims to provide a global overview of how digitalization and digital skills and competencies in higher education have been analyzed from a scientific perspective in recent years and what educational innovations and emerging technologies are in this field. Specifically, the aim is to observe the progress of this topic based on previous scientific literature according to the Web of Science (WoS) and Scopus databases between 2014 and 2023. That is, the current state of this topic is explored over the last ten years to shed light on current trends, developments and challenges of digitalization in the higher education environment. Regarding practical implications, this research seeks to identify emerging trends and innovations from new technologies in learning environments and to promote their application.

As for the novelty of this study, it is true that recent research has carried out bibliometric analyses on technological innovations in higher education, but these have only focused on a single scientific database (Díaz-García et al., 2022; Santoveña-Casal & López, 2024); a specific time period, such as Covid-19 (Brika et al., 2022; Sengupta & Vaish, 2023); or in some specific technology or tool (Fauzi et al., 2023; Oliveira et al., 2019; Reis-Marques et al., 2021). Therefore, it is important to analyze from time to time what is the state of the art of scientific production on digital innovations in higher education in a generic way, without limiting this search to a specific tool, temporary event or a single database, since existing studies in this regard have analyzed periods far removed from the current moment (Contreras et al., 2022; Zhang et al., 2018).

This paper is structured as follows: in this first section, the justification and interest of the topic analyzed are presented. In the second section, the methodology and the way of collecting the articles that make up the study sample are described. A third section shows the main results obtained from the review of bibliometric indicators obtained from the WoS and Scopus databases themselves and from the VOSViewer Software. Subsequently, the discussion of results will be shown and, finally, the main conclusions will be presented.

2. Methodology

Literature reviews play a fundamental role in academic research, allowing us to understand different aspects such as the general state of a field of research, identify the main topics studied, knowledge gaps and project new future lines of research (Sánchez et al., 2017; Snyder, 2019). It is necessary to carry out this type of analysis every certain period of time to organize and understand the set of information generated in a specific

field (Ozturk, 2021).

Although there is no consensus on the origins of bibliometric methods, the first study of this nature is usually considered to be the work carried out by Cole and Eales on the bibliography of anatomy, published in 1917 (Cole & Eales, 1917). Likewise, another author who analyzed the concept of bibliometrics in its first appearances in scientific literature was Pritchard (1969), who defined this concept as the science that studies the nature and evolution of a discipline, counting and studying its written content. Other more recent studies highlight this type of academic work for reasons such as the discovery of emerging trends in research, patterns of collaboration, components of a line of research, and to explore the structure of scientific works (Donthu, Kumar, & Pandey, 2021; Donthu, Kumar, Pandey, et al., 2021; Verma & Gustafsson, 2020).

Therefore, the main objective of a bibliometric analysis focuses on analyzing the state of the art of a certain field of research and observing, according to previous scientific literature, the different topics covered and future lines of research (Sánchez et al., 2017). According to numerous works, the main sections analyzed in this type of study usually refer to the number of publications, the productivity of the authors, the collaboration between authors, the number of citations received, the analysis of common keywords or the impact factor of the journals (Donthu, Kumar, Mukherjee, et al., 2021; Gallardo-Vázquez & Sánchez-Domínguez, 2023).

The data used in the present study come from the two main multidisciplinary databases of scientific literature, WoS from Clarivate and Scopus from Elsevier (Pranckutė, 2021; Vera-Baceta et al., 2019). After several refinements to obtain the correct results, the search equation used was as follows: "(educati*) AND (("higher education") OR ("higher educational institution*")) AND ((competec*) OR ("skill*")) AND (("digital*") OR ("technolog*") OR ("ICT*")) AND ((innovat*) OR (emerging))". This search equation was used to identify those documents that dealt with the topic of digital skills and competencies, ICTs and new innovative and emerging technologies in the higher education landscape. These concepts were searched for in the title, abstract and keywords. Likewise, to collect more articles that could make up the sample, snowball sampling was used, and the titles and keywords of the most cited articles found with the initial search were carefully read to include them in the search equation (Blanco-Zaitegi et al., 2022).

This search showed a total of 3441 results in WoS and 2241 in Scopus. The search was limited to scientific articles published in English and we selected all articles published from 2014 to 2023, the last complete year for which data were available. In addition, as regards the WoS database, only the database relating to the core collection (Core Collection) was selected. That is, other databases such as Medline, Scielo and Korean Citation Index were discarded. Subsequently, a new filter was performed excluding the documents returned that did not really correspond to scientific articles, but rather to book chapters, retracted articles, review articles, conference proceedings and editorial material, such as interviews or discussions. This new filtering returned 697 results in WoS and 755 articles in Scopus.

Once the search was completed, a scientific mapping was performed, which examines the connections between the components of the research, including citation analysis, co-citation analysis, bibliographic coupling, co-word analysis and co-authorship analysis (Donthu, Kumar, Mukherjee, et al., 2021). VOSviewer software, version 1.6.19, was used for mapping (CSTS, 2024). This is an open-source program that allows the analysis of bibliometric evolution by displaying different maps. Specifically, the program has three display modes: network, overlay and density, however, in this study, network visualization was used because it allows a simple observation of how keywords are related according to different categories or factors (van Eck & Waltman, 2010, 2017).

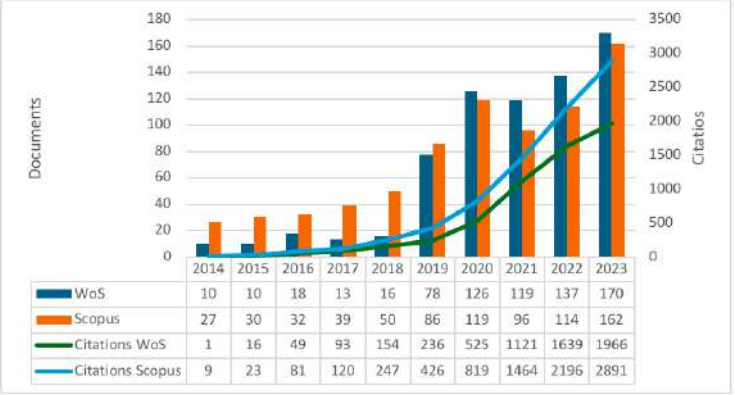
3. Results

As for the results, firstly, different data were analysed, based on information extracted from the WoS and Scopus databases, through their tool designed to analyze results from the databases themselves. The results obtained are presented in the following sections.

3.1. Number of publications and citations per year

The annual scientific production curve shows the results obtained by the search equation. Figure 1 shows the increase in publications on the subject of study in the study period, ten years between 2014 and 2023, both in Scopus and WoS, so it can be observed that there is great interest among researchers. In 2014 there were only 10 publications in WoS and 27 in Scopus; while, in 2023, the last year of our study, 170 publications were registered in WoS and 162 in Scopus.

As for the number of citations received annually, Figure 1 shows an exponential growth of citations in WoS and Scopus. The total number of citations recorded in the ten years analyzed was 5800 and 8276 in WoS and Scopus, respectively.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
WoS	10	10	18	13	16	78	126	119	137	170
Scopus	27	30	32	39	50	86	119	96	114	162
Citations WoS	1	16	49	93	154	236	525	1121	1639	1966
Citations Scopus	9	23	81	120	247	426	819	1464	2196	2891

Figure 1. Number of articles and citations per year. Source: Own elaboration based on WoS (2023) and Scopus (2023).

Additionally, Table 1 shows the ten most cited articles, differentiating between the two databases analyzed. The most cited article in both databases coincides, it is an article with 321 citations in WoS and 470 in Scopus that shows how the Covid-19 pandemic transformed higher education (Iivari et al., 2020). In addition, five of the ten most cited articles coincide in both databases (Blau et al., 2020; Bond et al., 2018; Iivari et al., 2020; Kruss et al., 2015; López-Pernas et al., 2019).

Papers References	Citations	Database
Iivari, N., Sharma, S., & Ventä-Olkkonen, L. (2020). *International Journal of Information Management, 55*.	794	WoS: 324; Scopus: 470
Bond, M., Marín, V. I., Dolch, C., Bedenlier, S., & Zawacki-Richter, O. (2018). *International Journal of Educational Technology in Higher Education, 15*(1).	427	WoS:176; Scopus: 251
Kruss, G., McGrath, S., Petersen, I.-H., & Gastrow, M. (2015). *International Journal of Educational Development*, 43, 22–31.	222	WoS: 99; Scopus: 123
López-Pernas, S., Gordillo, A., Barra, E., & Quemada, J. (2019). *IEEE Access, 7*, 31723–31737.	184	WoS: 76; Scopus: 108
Blau, I., Shamir-Inbal, T., & Avdiel, O. (2020). *Higher Education, 45*.	164	WoS: 69; Scopus: 95
Almeida, F., & Simoes, J. (2019). *Contemporary Educational Technology, 10*(2), 120–136.	121	Scopus
Orús, C., Barlés, M. J., Belanche, D., Casaló, L., Fraj, E., & Gurrea, R. (2016). *Computers & Education, 95*, 254–269.	110	WoS
Huda, M., Maseleno, A., Teh, K. S. M., Don, A. G., Basiron, B., Jasmi, K. A., Mustari, M. I., Nasir, B. M., & Ahmad, R. (2018). *International Journal of Emerging Technologies in Learning, 13*(5), 71–85.	102	Scopus
Patil, U., Kostareva, U., Hadley, M., Manganello, J. A., Okan, O., Dadaczynski, K., Massey, P. M., Agner, J., & Sentell, T. (2021). *International Journal of Environmental Research and Public Health, 18*(6).	100	Scopus
Tejedor, S., Cervi, L., Tusa, F., & Parola, A. (2020). *Revista Latina de Comunicacion Social, 78*, 1–21.	99	WoS

Table 1. The ten most cited articles in the WoS and Scopus databases. Source: Own elaboration based on WoS (2023) and Scopus (2023).

3.2. Most productive authors and editorial activity of the journals

Next, the main authors and scientific journals that most deal with the topic of the use of ICT technologies and digital skills and abilities to improve innovation in learning in higher education were analyzed. Regarding the most prolific authors, many similarities can be observed between the two databases, with the authors Camacho-Zuñiga, C., Caratozzolo, P., Franco M., Membrillo-Hernández, J., Morales-Menéndez, R, and Ramírez-Montoya, M.S. coinciding in both databases. Table 2 shows the number of articles contributed by each author.

Number of documents			
WoS		Scopus	
Ramírez-Montoya, M.S	11	Ramírez-Montoya, M.S.	7
Membrillo-Hernández, J.	5	Membrillo-Hernández, J.	5
Caratozzolo, P.	4	Morales-Menéndez, R.	5
Franco, M.	4	Caratozzolo, P.	4
Garcez, A.	4	Hernandez-de-Menéndez, M.	4
Lara-Prieto, V.	4	Khlaisang, J.	4
Morales-Menéndez, R.	4	Abbas, A.	3
Silva, R.	4	Akhmetshin, E.M.	3
Alfaro-Ponce, B.	3	Camacho-Zuñiga, C.	3
Camacho-Zuñiga, C.	3	Franco, M.	3

Table 2. Most productive authors. Source: Own elaboration based on WoS (2023) and Scopus (2023).

Additionally, Table 3 provides information regarding the main journals with the highest number of publications on the subject of study. The journals that match in both databases are Education and Information Technologies, Education Sciences, Frontiers in Education., Frontiers in Psychology, Higher Education Skills and Work Based Learning, International Journal of Emerging Technologies in Learning, International Journal on Interactive Design and Manufacturin y Sustainability.

WoS		Scopus	
Sustainability	43	Sustainability	35
Education Sciences	20	Education Sciences	18
International Journal of Interactive Design and Manufacturing	14	International Journal of Emerging Technologies in Learning	14
Frontiers in Education	13	Education and Information Technologies	13
Education and Information Technologies	12	International Journal on Interactive Design and Manufacturing	12
Ad Alta Journal of Interdisciplinary Research	9	Frontiers in Education	9
Frontiers in Psychology	9	Frontiers in Psychology	8
Higher Education Skills and Work Based Learning	8	Electronic Journal of E-Learning	7
Information Technologies and Learning Tools	8	European Journal of Contemporary Education	7
International Journal of Emerging Technologies in Learning	8	Higher Education Skills and Work Based Learning	7

Table 3. Most productive journals. Source: Own elaboration based on WoS (2023) and Scopus (2023).

3.3. Publishing activity by country and activity by thematic categories

Regarding the countries where the largest number of articles have been published, they are Spain, the United States and Mexico in both databases, as can be seen in Figure 2.

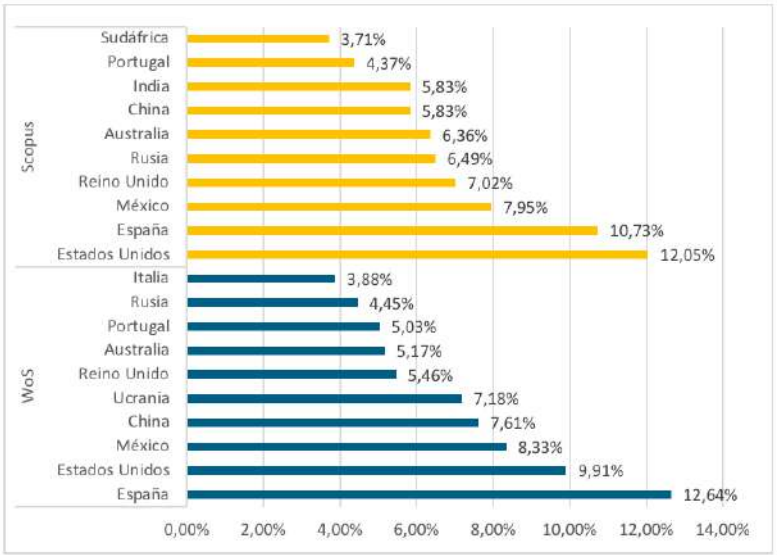


Figure 2. Most productive countries. Source: Own elaboration based on WoS (2023) and Scopus (2023).

Table 4 shows the categories under which the different articles in our samples from both databases are found. Thus, in WoS the most frequent category is "Education Educational Research" with 41.8% of the articles in the sample, followed by "Environmental Sciences" and "Green Sustainable Science Technology" with 7.8% and 7.5%, respectively. On the other hand, in Scopus the most popular categories are "Social Sciences", "Computer Science" and "Engineering" with 47.3%, 14.4% and 9.10%, respectively.

		Documents	% of the sample
WoS	Education Educational Research	291	41,80%
	Environmental Sciences	54	7,80%
	Green Sustainable Science Technology	52	7,50%
	Environmental Studies	45	6,50%
	Management	42	6%
	Computer Science Information Systems	31	4,50%
	Business	31	4,50%
	Information Science Library Science	30	4,30%
	Education Scientific Disciplines	28	4%
	Multidisciplinary Sciences	25	3,60%
Scopus	Social Sciences	524	37,30%
	Computer Science	202	14,40%
	Engineering	128	9,10%
	Business, Management and Accounting	116	8,30%
	Environmental Science	63	4,50%
	Energy	44	3,10%
	Psychology	43	3,10%
	Arts and Humanities	42	3%
	Economics, Econometrics and Finance	40	2,80%
	Mathematics	34	2,40%
	Health Professions	29	2%

Table 4. Main categories of WoS and Scopus databases. Source: Own elaboration based on WoS (2023) and Scopus (2023).

The results obtained with the VOSviewer program are presented below.

3.4. Co-occurrence of keywords

The analysis of the set of keywords allows us to identify the main lines of research that are developed in

the scientific literature (Abad-Segura et al., 2006). Thus, in order to observe the evolution of trends in this field of research, two independent analyses were carried out in WoS and Scopus. These keywords and their relationships in the two databases analyzed are shown in the following paragraphs.

Figures 3 and 4 represent the major themes grouped according to the different lines of research. These are represented through the nodes, in such a way that a node with a larger size than the rest means a greater presence and research in the previous literature. In turn, the position of the nodes is also important; the more central a node is in the bibliometric map, it means that it is more closely related to the other clusters (van Eck & Waltman, 2010, 2017).

Regarding the results, on the one hand, the number of keyword co-occurrences in WoS is 3033 where at least 20 keywords appear together in the title, abstract or keyword list. Only 25 words met the required threshold and were grouped into 3 groups. These groups reveal three different possible research fields. The first group (green color) focuses on the field of keywords revealed such as "university", "innovation", "employability", "framework" and "science", among others. The second group (red color) relates the two most representative keywords of this study, "students", "perceptions", "skills", "performance" or "impact". And the third group (blue color) includes words such as "higher education", "technology", "educational innovation", "teachers", "ICT" or "covid-19" (Fig. 3).

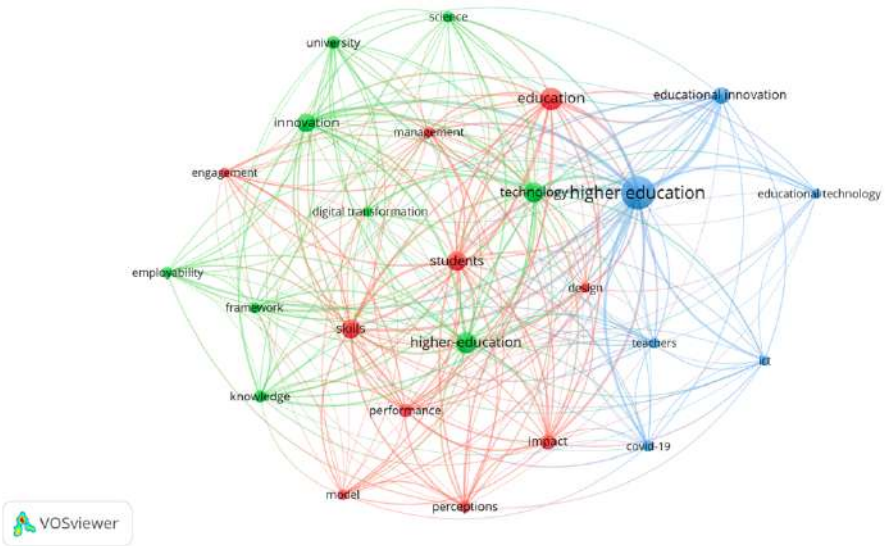


Figure 3. Representation of the keyword network in WoS (WoS, 2023). Source: VOSviewer.

On the other hand, the number of keywords in Scopus is 3586, in which at least 20 keywords appear together in the title, abstract or keyword list. According to the above, 29 words met the required threshold, being grouped into two groups that would be identified with two possible different research streams. The first group (red color) relates keywords such as "students", "e-learning", "online learning", "educational technology" or "educational innovation". On the other hand, the second group (green color) includes words such as "teaching", "students", "university", "curriculum", "training", "learning" or "university" (see Fig. 4).

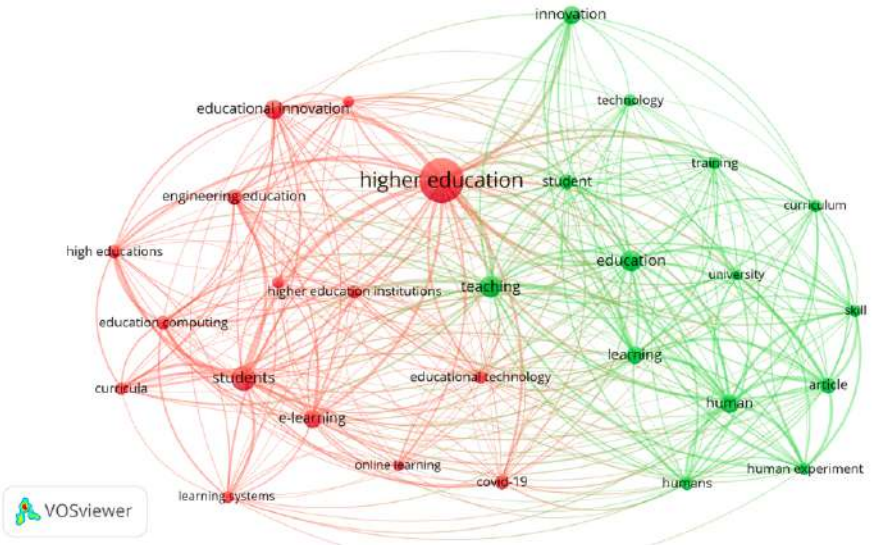


Figure 4. Representation of the keyword network in Scopus (Scopus, 2023). Source: VOSviewer.

3.5. Co-authorship analysis: international production and relationship between countries

VOSviewer allows you to analyze the relationships between authors from different countries. In particular, the co-authorship analysis allows you to check the social interaction between different authors, affiliations or countries (van Eck & Waltman, 2010). In particular, according to the WoS database, the present study covered 99 countries. The authors set a threshold of at least 10 articles per country and at least 100 citations received by the articles in that country. Specifically, 19 countries met this criterion. Table 5 shows the top 10 countries that meet this criterion in WoS and that have the highest number of documents and citations.

Country	Documents	Citations
Spain	88	1158
USA	69	826
Mexico	58	535
Peoples China	53	444
Ukraine	50	115
England	38	496
Australia	36	301
Portugal	35	223
Italy	26	296
South Africa	26	211

Table 5. Top 10 most cited and productive countries according to WoS (WoS, 2023). Source: Own elaboration from VOSviewer.

A map was also created using VOSviewer showing the main authorship relationships between the 19 countries resulting from the analysis (Fig. 5).

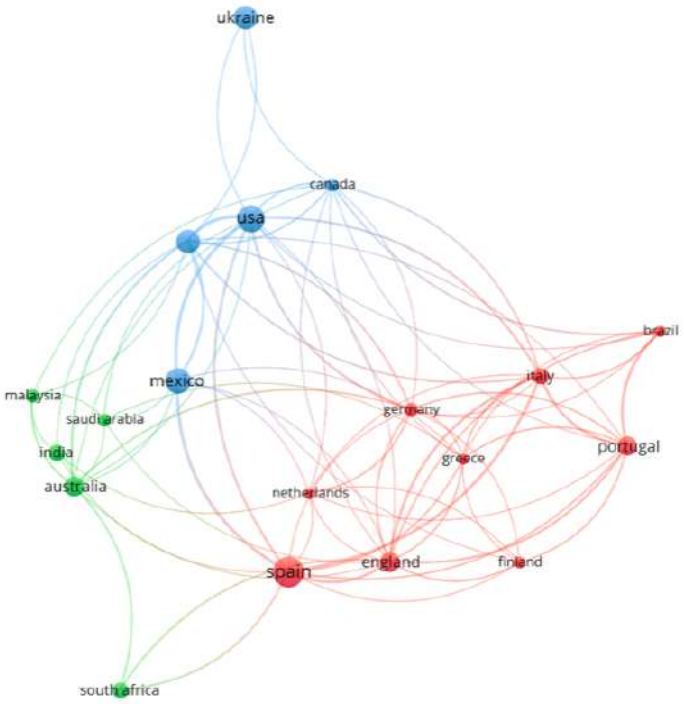


Figure 5. Collaboration between the most cited and productive countries in WoS (WoS, 2023). Source: VOSviewer.

As can be seen in Figure 5, the countries formed three collaboration groups, which are distinguished by different colors. On the one hand, there is the group led by Spain, the United Kingdom and Portugal; in second place, the group led by the United States, Mexico and Ukraine; and in third place, South Africa, Australia and India, among other countries.

On the other hand, according to the Scopus database, the present research covered 93 countries. The authors established a threshold of a minimum of 10 articles per country and a minimum of 100 citations received by the articles from that country. Specifically, 25 countries met this criterion. Table 6 shows the top 10 countries that meet this criterion in Scopus and that have the highest number of documents and citations.

Country	Documents	Citations
United States	91	1636
Spain	81	1114
Mexico	60	817
United Kingdom	53	831
Russian Federation	49	355
Australia	48	652
China	44	412
India	44	235
Portugal	33	316
South Africa	28	376

Table 6. Top 10 most cited and productive countries according to Scopus (Scopus, 2023). Source: Own elaboration from VOSviewer.

In addition, a map was created using VOSviewer showing the main authorship relationships between the 25 countries resulting from the analysis according to the Scopus database (Fig. 6). First, there is the group

headed by Spain, Mexico and France; second, the group led by the United States, China and Russia; third, a group mainly made up of different European countries, such as Portugal, Germany, or Finland, among other countries; and fourth, a group led by countries such as the United Kingdom, South Africa and Australia.

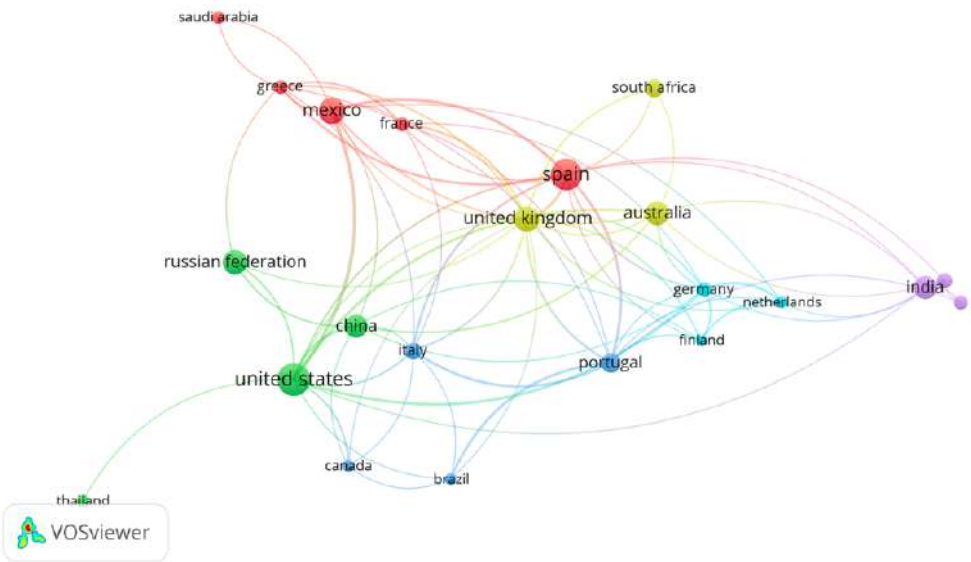


Figure 6. Collaboration between the most cited and productive countries according to Scopus (Scopus, 2023). Source: VOSviewer.

3.6. Co-citation analysis

Co-citation analysis allows determining the correlation between the most cited authors, references or journals through the proximity distance observed on the corresponding map (van Eck & Waltman, 2010, 2017). In this study, the different cited authors were used as a unit of measurement. That is, the smaller the distance between the names of the authors, the greater the strength of the co-citation and the probability that they are semantically related, such that it is likely that the articles of the researchers who co-cite each other address similar or related ideas (Boyack & Klavans, 2010).

According to the WoS database, the present research covered 25,468 authors. A minimum threshold of 25 citations received from each author was set. Specifically, 14 authors met this criterion. Figure 7 shows the relationships between these authors and Table 7 shows the authors who received more than 30 co-citations.

Author	Co-citations
OECD	73
European Commission	67
UNESCO	57
Hair, J.F.	52
Creswell, J.W.	41
Etzkowitzr, H.	38
Braun, V.	34
Bandura, A.	33
Venkatesh, V.	32
Garrison, D. R.	31

Table 7. Co-citation analysis by authors in WoS (WoS, 2023). Source: Own elaboration from VOSviewer.

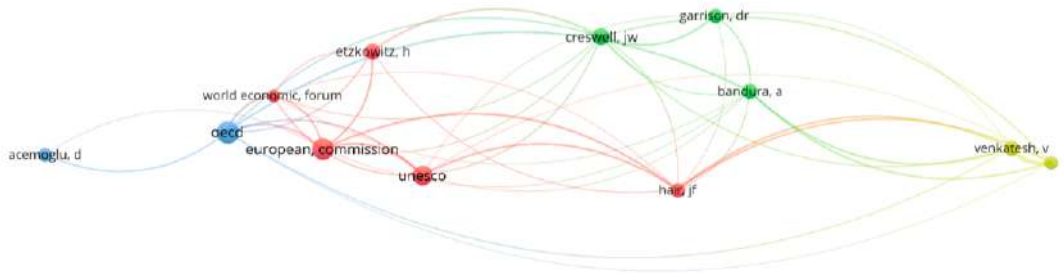


Figure 7. Co-citation analysis by authors in WoS (WoS, 2023). Source: VOSviewer.

Regarding the Scopus database, the present study included 48,873 authors. Again, a minimum threshold of 25 citations received from each author was established. Specifically, 33 authors met this criterion, and the relationships between these authors are shown in Figure 8. Likewise, Table 8 shows the authors who have more than 30 co-citations.

Author	Co-citations
Creswell, J.W.	52
Ramirez-Montoya, MS.	42
Venkatesh, V.	41
Hair, J.F.	39
Davis, F.D.	39
Mishra, P.	39
Garrison, D.R.	36
Etzkowitz, H.	36
Liu, Y	34
Li, L.	32
Sarstedt, M.	31
Huda, M.	31
Punie, Y.	31
Punie, Y.	31

Table 8. Co-citation analysis by authors in Scopus (Scopus, 2023). Source: Own elaboration from VOSviewer.

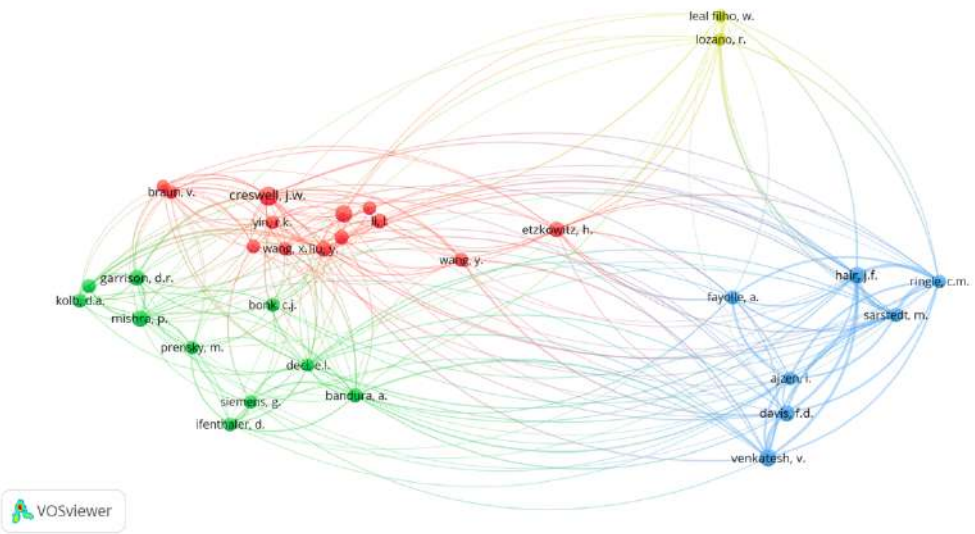


Figure 8. Co-citation analysis by authors in Scopus (Scopus, 2023). Source: VOSviewer.

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4. Discussion

In line with previous studies, new technologies have had a considerable impact on all aspects of society. The educational environment is no exception, which imposes the need for higher education institutions to adopt methodological innovations to respond to the changing educational landscape through digital teaching competence and its five areas of recognition (Alfaro-Ponce et al., 2023; Kruss et al., 2015; Pérez-Calderón et al., 2021; Prieto-Ballester et al., 2021). Consequently, this evolution has been reflected in the increase in the publication of scientific articles in the two main scientific reference databases. In other words, the scientific production associated with the management of digital competences and/or skills and the use of ICT in higher education to improve pedagogical innovation and learning has increased considerably. The increase in the number of articles published in both databases denotes that there is a high interest among researchers, especially since 2019, a fact that may be due to the proliferation of numerous scientific articles on the acceleration of the virtualization of teaching during the beginning of the Covid-19 pandemic, as shown by several studies (Guillén-Yparrea et al., 2023; Karademir et al., 2020; Khan et al., 2022; Martzoukou, 2020). In fact, according to the analysis of the most cited articles in both databases, the document that accumulated the highest number of citations in the period analyzed deals with a study that addresses the digital transformation of education caused by the Covid-19 pandemic in Finland and India (Iivari et al., 2020). The study concluded that there is a large digital divide and that not all students were on equal terms to participate in a digitalized basic education, which should make school managers and politicians reflect on providing extra support to families with fewer resources in investments related to access to equipment, technology and training.

Likewise, according to the results obtained with the VOSViewer software, different keywords were identified in both databases during the period analyzed that are related to the main lines of research studied by the researchers. From the results it can be seen that, according to the number of occurrences of keywords, the majority of scientific production is associated with terms such as technology, innovation, perceptions, students or teaching, with research on topics such as entrepreneurship, sustainability, blended learning, virtual reality or education 4.0 still incipient. In this sense and in line with other studies, it is essential that topics such as these are addressed by scientific literature, since, in the case of Education 4.0, it prepares new generations to develop the skills necessary to perform in the current panorama marked by technology and constant dynamism (Almeida & Simoes, 2019; Matsumoto-Royo et al., 2021).

The appearance of the word "students" reveals that, in comparison, the perspective associated with the teaching staff has not been sufficiently investigated. Without a doubt, one of the main factors in the advances in the virtualization and digitalization of higher education would be the commitment, training and adaptation of the teaching staff. Teachers are responsible for the introduction of new methodologies in the classroom and, therefore, for the use and experience of students with new training techniques that will require new skills. In this sense, it would be interesting to investigate whether a more professional or research profile of teaching staff than an academic one would be better trained and predisposed to the use of new methodologies and ICTs applied to their teaching. It would also be interesting to analyze to what extent the generational leap of the teaching staff or the purchasing power of the institutions are slowing down the virtualization and digitalization of higher education. On the other hand, the appearance of new research that relates innovation in the framework of higher education and employability is also noteworthy (Li et al., 2022; Pilav-Velic et al., 2020). Thus, the results of some studies determine that graduates whose teaching/learning process has been based on various innovations find employment more quickly (Pilav-Velic et al., 2020). Along the same lines, other studies highlight the importance of digital skills in employability, with the capacity for innovation and social adaptability being especially relevant in times when information technology and the knowledge-based economy prevail (Gupta & Mahajan, 2024; Li et al., 2022). Thus, in line with Valencia-Arias et al. (2023), collaboration between universities and companies is necessary in terms of improving educational programs to increase employability, since, as some studies suggest, higher education contributes to economic development and productivity through education, skills or innovation (Kong et al., 2022; Kruss et al., 2015). Ultimately, in all these aspects there is a common denominator that needs to be addressed: digital literacy for both teachers and students (Blau et al., 2020; Martzoukou, 2020).

It is also striking that among the main keywords identified in this study, some terms have not appeared or have a low prevalence or number of occurrences, such as GPT Chat, artificial intelligence or augmented reality, since they are tools that are attracting public attention and allowing novel applications in various areas of human activity, such as education (Bauer et al., 2023). These are probably terms that will be dealt with more in future studies due to the short time they have been used in higher education. Adapting to these new ICT tools will be a great challenge, particularly for teachers, due to the great speed at which they evolve and change.

5. Conclusions

In this research, a quantitative bibliometric analysis is carried out to observe the state of the art and research trends on the management of competencies, digital skills and the use of ICT in higher education. The growing interest on the part of the scientific community in this topic is reflected in the increase in the number of articles published and the number of citations they receive, with the considerable increase in scientific production as a result of the Covid-19 pandemic being of special relevance. This makes the digitalization of higher education and everything that it entails a field of recent and growing interest in scientific literature.

The academic contribution of this study would be to show what the recent trends are among researchers in order to continue researching this topic. Specifically, reference is made to the most cited studies, the most productive journals and the gaps in previous research, which can help researchers choose an appropriate topic and scientific journal to publish their work.

It is undeniable that teaching-learning methods and strategies are constantly evolving as a result of technological development. Likewise, higher education institutions must adapt to changes and train higher education students to acquire the skills and abilities that are demanded in the contemporary labor market, since, in line with previous studies, globalization and the technological development we are witnessing require highly trained employees (Pârvu et al., 2014; Valencia-Arias et al., 2023). In this sense, the application of new technologies in the world of work has revolutionized traditional ways of working and created new forms of work, with the improvement of higher education programs being essential to increase such employability. In this regard, one of the consequences of digitalization in the labor market is the emergence of teleworking, the performance of which would be impossible without the acquisition of the necessary digital skills. This modality results in numerous advantages for society, such as the reconciliation of personal and family life with work life or the repopulation of rural areas through remote work from any location.

In line with previous research analysed in this bibliometric analysis, this work shows that it is necessary to promote innovations in the educational landscape, as educational institutions must be prepared to face crises and adapt to new challenges. On the other hand, we must not forget the magnitude of the positive impacts produced as a result of digitalization, such as better learning, teamwork and a more enriching interaction between teachers, students and content (Blau et al., 2020; López-Pernas et al., 2019; Tóth-Pajor et al., 2023). However, as some studies point out, we consider that one of the main challenges we face is the possible problem that some people have with access to, the use of technology, as well as with the skills and competencies necessary to integrate digital tools into learning practices, and there may be a large digital divide in this regard (Iivari et al., 2020). Technology itself can overcome accessibility barriers. However, it is the managers of institutions and university centers, as well as policy makers, who must offer support measures in financing or providing funds to facilitate access to the equipment, technology and connectivity that the virtualization of higher education currently requires.

In short, new technologies offer important opportunities in teaching and learning and keep the educational environment at the forefront, since it requires teachers to stay up to date on this topic, resulting in a quality teaching-learning process. In many cases, teacher training in the use of digital resources is insufficient, showing a great inequality between the skills of students and teachers. Therefore, a correct identification of training needs in digital skills by teachers is necessary, as well as adequate training that allows them to adapt to new

training scenarios and respond to the needs of students. In this regard, one solution would be the proposal of personalized training itineraries.

Finally, this research has some limitations that also open up future lines of research. Firstly, only research articles have been considered. Other types of highly relevant scientific documents, such as conference proceedings, reviews, letters or notes, would offer interesting information in future studies. Secondly, the only databases analysed have been WoS and Scopus, which has meant discarding valuable information offered by other repositories such as Google Scholar, Scielo, among others. And, finally, in future research other software could be used for data analysis that would offer a different view of the results obtained.

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