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APPLICATION OF BIBLIOMETRIX SOFTWARE AND SCIENTIFIC REVIEW IN TECHNOLOGY AND EDUCATION FIELD

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ABSTRACT

Technological competences are related to various thematic lines of impact for students, teachers, and professionals. The growing interest in recent years and the demand of the educational society, leads to the need to evaluate the research process that draws a map of the published scientific literature. The research focuses on a systematic bibliometric analysis, which generates a state of the art of the topic: 'Technology, education and teaching'. A methodology has been developed based on the Bibliometrix tool for R language, with the IDE R-Studio development interface, completed with an analysis process through the BiblioShinny web environment. The corpus extracted from Web of Science (subject: Social Sciences) in a time frame from 1980 to 2023 is 1889 scientific articles. The results provide a comprehensive mapping of notable authors, relevant journals, changes in thematic trends, and the social structure of inter-university and international collaborations.

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1. Introduction

The arrival of the European Higher Education Area (EHEA) at the end of the 20th century marked a change in the educational paradigm, redefining the need to promote cross-cutting skills, particularly information technology and digital literacy. To analyze the state of digitization and literacy in universities, the Digital Maturity Model for Universities (md4u) was developed, which allows progress to be measured using a set of best practices related to management, innovation, governance, and digital transformation. The main contributions of this 2022 report highlight the need to increase technological skills among students, as well as the stimulation of technological entrepreneurship and research into new methodologies associated with the acquisition of these skills (Spanish Universities [CRUE], 2022). To achieve these objectives, it is essential to consider digital transformation as a key variable for the advancement of education, as numerous authors affirm: "digital transformation has laid the foundations for the integration of information and communication technologies in educational contexts" (Cabero-Almenara, 2020, p. 5).

The analysis of the factors that drive the correct implementation of technology in classrooms requires consideration of key elements such as organizational variables and technologies, teacher training, and the selection of appropriate digital tools and resources (Ghitis-Jaramillo & Vásquez, 2019). This analysis involves investment in scientific research on the impact of technological methodologies on teaching and learning (Paguay et al., 2022; Rodríguez García et al., 2019; Salas & Lugo, 2018), technological tools in research (Vega Umaña & Barrantes Aguilar, 2022), new challenges (Cabero Almenara et al., 1994), and assessment systems with technological tools (Carrascal Domínguez & García Fandiño, 2023).

Scientific production in any field must be based on a correct state of the art that provides researchers with an adequate framework for creating a solid foundation in relation to contextualization, the identification of unexplored areas, methodologies, and the description of relevant concepts and theories in the field.

Systematic reviews are a fundamental resource for constructing the state of the art, as they are rigorous methods for collecting, evaluating, and synthesizing existing scientific output in a specific field (Grant, 2009). They also provide rigor for identifying the most relevant research: "Literature reviews play an essential role in the advancement of science due to its cumulative nature" (Codina, 2020, p.141).

The research we present has been carried out through a systematic, reproducible, and objective literature review, which facilitates the elimination of sample selection bias (Khan et al., 2022). The methodology used is appropriate for identifying the performance of scientific literature, co-authorships, co-citation trends, and research trends in specific fields (Kent-Baker et al., 2020).

The results obtained will provide relevant information for creating a state of the art based on a systematic review. To this end, we took as our starting point a very extensive corpus of analysis (NP=1889), which will allow us to analyze the most relevant variables on the subject: "Technological competencies in education", based on a bibliometric analysis methodology using the Bibliometrix tool.

2. Methodology

2.1. Objectives

The overall objective of this research is to conduct a systematic review of the scientific literature published in Spanish on the subject of "Technological skills in education" in the field of Social Sciences.

To this end, the following specific objectives have been set, in line with the subject under investigation:

- Measure the productivity of authors, universities, and publication sources

- Determine the social structure (networks of associations between institutions/authors/countries)
- Define the conceptual structure
- Carry out temporal and geospatial analysis

2.2. Methodological design

The software selected for the literature review process is the Bibliometrix package for the R language, with the R-Studio development interface, which was completed with an analysis process through the BiblioShinny web environment (Aria & Cuccurullo, 2017). This tool allows for the analysis of open language environments and ecosystems, being one of the most powerful and flexible statistical software environments (Rodríguez-Soler et al., 2020) for analyzing bibliometric data with objective and quantitative criteria (Donthu et al., 2021; Kent-Baker et al., 2020; Khan et al., 2022; Owolabi & Sajjad, 2023; Rodríguez-Soler et al., 2020) and providing comprehensive scientific mapping (Aria & Cuccurullo, 2017).

The research corpus has been extracted from the Web of Science collection, a database that stands out as one of the largest and most highly rated, especially in the field of social sciences (Li & Hale, 2016; van Nunen et al., 2018).

The selected corpus comprehensively covers publications released between 1980 and 2023 in the field of social sciences. After applying the cleaning filters, the total number of publications analyzed is 1,889 scientific documents (NP=1,889).

The systematic bibliometric analysis methodology (Zupic & Carter, 2015) was carried out in five phases: study design; data collection; data analysis; data visualization; and interpretation.

Phase 1. Study design: through an exploratory study in which a total of seven scientific production databases were analyzed, yielding vital data regarding the most prominent keywords and most representative databases. After selecting the two most prominent databases and applying filters, a prospective search was conducted, yielding 1,302 results in the Scopus database compared to 1,889 in the Web of Science collection.

Phase 2. Data collection: The data was extracted entirely from the Web of Science (WOS) database using the following inclusive criteria:

Time period: from 1980 to 2023

Language: Spanish

Field: Topic (title, abstract, keywords, keyword plus)

Key: "Technology and education and teaching"

Subject: Social sciences

The complete records (NP=1889) were downloaded, including references, in download blocks of 500 results in BibTex format. The data was filtered by correcting homonyms or authors with multiple spellings. This was done manually, checking the full name, ORCID, and affiliation.

The data obtained after cleaning is shown in the following table (Table 1):

Table 1. Key information on basic performance

Description	Results
Timespan	1980:2023
Sources (Journals, Books, etc)	393
Documents	1889
Annual Growth Rate %	8.06
Document Average Age	4.9
Average citations per doc	3.149
References	47079
DOCUMENT CONTENTS	

Keywords Plus (ID)	669
Author`s Keywords (DE)	3695
AUTHORS	
Authors	4239
Authors of single-authored docs	373
AUTHORS COLLABORATION	
Single-authored docs	373
Co-authors per Doc	2.62
DOCUMENT TYPES	
Article	1668
Article; book chapter	25
Article; proceedings paper	2
Book	1
Editorial material	6
Editorial material; book chapter	1
proceedings paper	135
Review	51

Source: Own elaboration, 2024.

Phase 3. Data analysis using Biliometrix software for R language, with the R-Studio development interface, which was completed with an analysis process through the BiblioShinny web environment. We performed two types of analysis: production and relationships (Cobo et al., 2011). The production analysis is statistical in nature and includes the volume of documents per author, institution, or country and the number of citations. The relational analysis addresses the social and conceptual structure of publications using mapping techniques.

The unit of analysis was described based on keywords, which allowed us to create networks conducive to the analysis of bibliographic coupling, co-citation, collaboration, and concurrence, essential data for analyzing changes in the paradigm, current research sources, conceptual visualization, temporal/geospatial analysis, and social structure.

A citation analysis is performed, consisting of counting citations as a measure of similarity between documents, authors, and publications (Aria & Cuccurullo, 2017). This analysis provides information on bibliographic coupling (analysis of citing documents) and co-citations (analysis of cited documents), which is useful in recognizing social structure. The analysis of both variables will also allow us to map the temporal and geospatial evaluation.

After creating the networks, a normalization process was performed on the relationships and their nodes using the normalize similar function and calculating the similarity average.

Phase 4: Data visualization: a conceptual structural mapping and a network mapping are generated from the Biblioshinny environment executed with the Bibliometrix library through RStudio.

3. Analysis and results

3.1. Analysis of basic performance

The recovery of data from 1980 to 2023 (Table 1) yielded a total of 1,889 publications (NP=1,889) distributed across a total of 393 different sources (S=393). The distribution by type shows significant differences, with very significant percentages of production in relation to publication

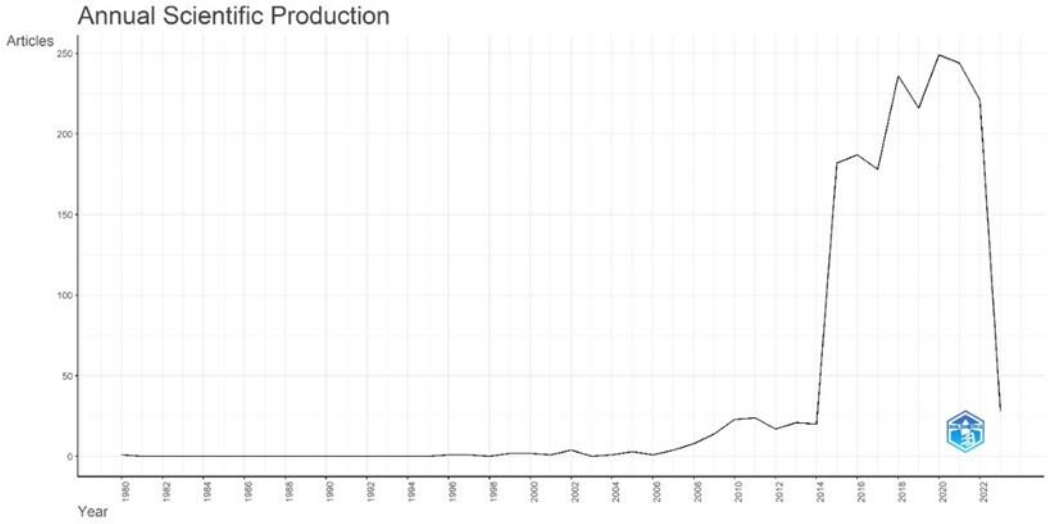
in journals (88%), compared to very insignificant percentages in the rest of the scientific literature. Of note is the low representation of publications in books.

Looking at more general values, the annual growth rate of scientific literature is around 2.3% (Boissier, 2013). If we focus on more specific areas such as sustainable energy, the rate is slightly higher at 2.59% (Kemeç & Altınay, 2023), while in other areas such as research related to private enterprise (Pereira & Franco, 2022) or under the topic of aphasia disorders (Wei & Jiang, 2023), the data is below 1.41% growth in the production rate.

The growth rate in the subject analyzed (AGR=8.06) indicates that this knowledge is undergoing rapid development in terms of scientific production compared to the overall average of other disciplines.

The temporal analysis (Figure 1) shows a wide dispersion in the distribution of the growth rate according to the number of publications per year (σ=81.84), with the period 2015 to 2022 being the most representative. The first clear sign of scientific production in this subject coincides with the arrival of the EHEA educational reform, which highlights the importance of including technology skills. In the case of Spain, the restructuring of the university system was completed in the 2010-2011 academic year. the mapping shows a clear upturn from this period, which consolidated in 2015 (NP=182) and reached its peak in 2020 (NP=249) and 2021 (NP=244), possibly due to the COVID social and health crisis. In subsequent years (2022 to 2023), production declined significantly.

Figure 1. Temporal analysis of publications by year.



Source: Own elaboration, 2024.

3.2. Analysis of publication sources

To analyze the quantitative distribution by publication type clusters (Table 2), Bradford's Law (Yatsko, 2012) was used, which states that, in any field of knowledge, there is typically a central group of sources that publish most of the articles, and from this central group there is a dispersion of articles and journals. The law orders sources by number of publications and groups them into three zones (Table 2):

Zone 1: contains a small number of journals in which most of the scientific literature is published; these are the most relevant and prestigious in the field analyzed.

Zone 2: intermediate zone of the law, contains a greater number of journals than zone 1, but the number of documents published on the subject is lower.

Zone 3: contains a large number of journals with few articles published on the area analyzed.

Table 2. Distribution of scientific production according to source: Bradford's Law.

Zone	Number of journal (NS)	Number of paper (NP)	Bradford multiplier
1	20	628	-
2	60	642	3
3	313	619	5.22
Total	393	1889	

Source: Own elaboration, 2024.

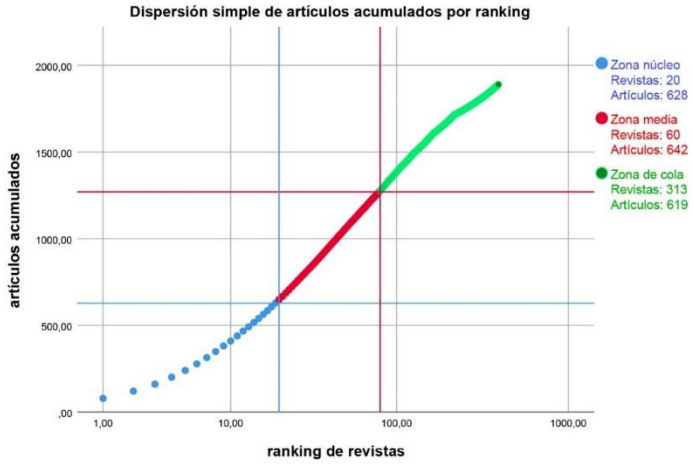
Compliance with the Bradford Law follows the $1:n:n^2$ model, where n is obtained from the ratio of sources in zone 2 to zone 1 (n=60/20=3) (Kumar, 2018), so for strict compliance with the number of articles, zone 3 should have 20(3)2, which results in 180, considerably lower than the 313 journals found.

The error is calculated using the average of the Bradford multipliers, resulting in n=4.11. Thus: $1: n: n^2: 20: 20*4.11: 20*(4.11)^2: 20: 82.17: 337.57 >> 439.74$.

Finally: [(439.74-393) /393]*100=11.89%

This data indicates that there is an 11.89% growth in the number of publications in peripheral journals, which could represent a change in the distribution of scientific literature, suggesting that a greater proportion of articles are being published in peripheral journals compared to central journals (Figure 2). This shift in distribution could reflect significant changes in the way scientific information is produced, distributed, and accessed.

Figure 2. Graphical representation of Bradford's Law.



Source: Own elaboration, 2024.

The distribution of sources (Table 3) reflects a preference for articles over other types of publications: 34% are concentrated in 20 sources distributed among journals (N=18), conference proceedings (N=1), and training materials (N=1). Of the 18 journals in “zone 1”, 15 are Spanish, 2 are Cuban, and 1 is Colombian.

Table 3. Sources located in Bradford zone 1.

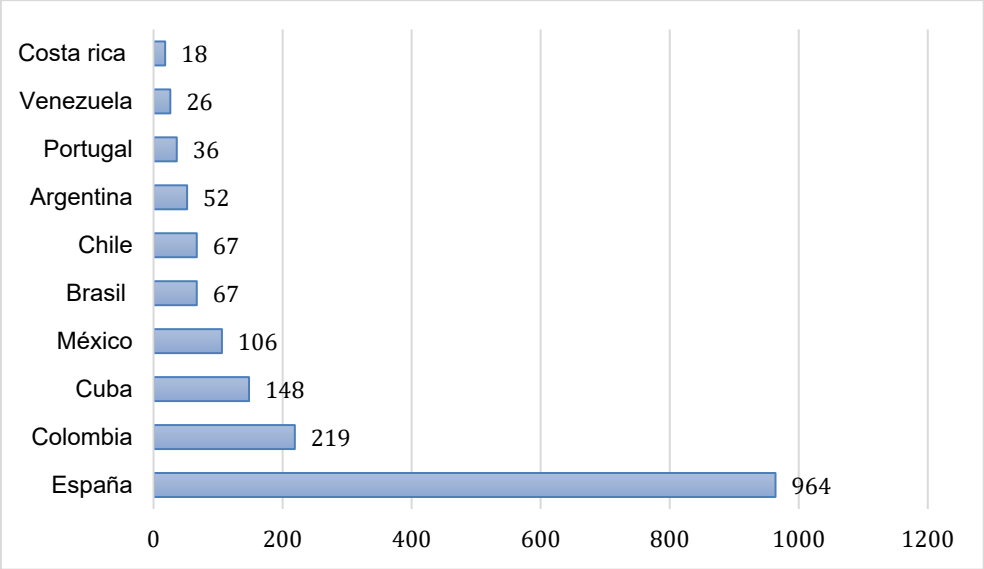
Sources	Np
Revista Conrado	79
Ried-Revista Iberoamericana de Educación a Distancia	42
Revista Latinoamericana de Tecnología Educativa-Realtec	40

Revista Universidad y Sociedad	40
Red-Revista de Educación a Distancia	39
Actas del Congreso Virtual: Avances en Tecnologías, Innovación y Desafío de la Educación Superior (Atides 2018)	38
Campus Virtuales	36
Pixel-Bit-Revista de Medios y Educación	35
Edmetic	32
Comunicar	29
Profesorado-Revista de Curriculum y Formación de Profesorado	29
Revista de Educación	28
Revista Complutense de Educación	25
Virtualidad Educación y Ciencia	25
Educación XX1	23
Revista Educación	23
Digital Education Review	22
Redu-Revista de Docencia Universitaria	22
Ijeri-International Journal of Ediucational Research and Innovation	21

Source: Own elaboration, 2024.

The number of highly specialized journals on the subject is concentrated in two countries: Spain and Cuba, with Spain being the most specialized area in terms of the number of publications. The geographical distribution of scientific production in total publication counts is similar to the results obtained with the Bradford matrix: the three most relevant countries are Spain, Colombia, and Cuba (Figure 4). Although Colombia has 219 articles, only the “Revista Educación” is in zone 1, with the rest basically in zone 3, indicating a wide dispersion in the specialization of publication sources.

Figure 4. Geographic distribution of countries with the highest scientific output.



Source: Own elaboration. 2024.

To analyze the impact of sources, both global and local citations have been used as references. Globally cited references include all citations that could appear in any document. Local citations focus only on those that appear within the processed sample (Gil et al., 2020).

The correlation coefficient—denoted as R—between the number of publications (NP=1,889) and global citations (Global Cit=5,629) is R=0.87. This correlation coefficient indicates a strong positive association between the number of articles published and the number of citations received. This suggests that there is a significant and positive correlation between the growth in the number of publications and the number of citations those articles have received globally. This strong correlation implies that articles dealing with technology and teaching have a considerable impact, which in turn implies substantial interest in research carried out in this area.

In the analysis carried out using local citations as a reference, a total of 5,949 citations were found (Local Cit= 5,949). The journal Comunicar ranks first with a total of 988 citations and an average of 29, 2.1% more than the second journal, Ried (Table 4).

Tabla 4. Impact of major sources on local citations.

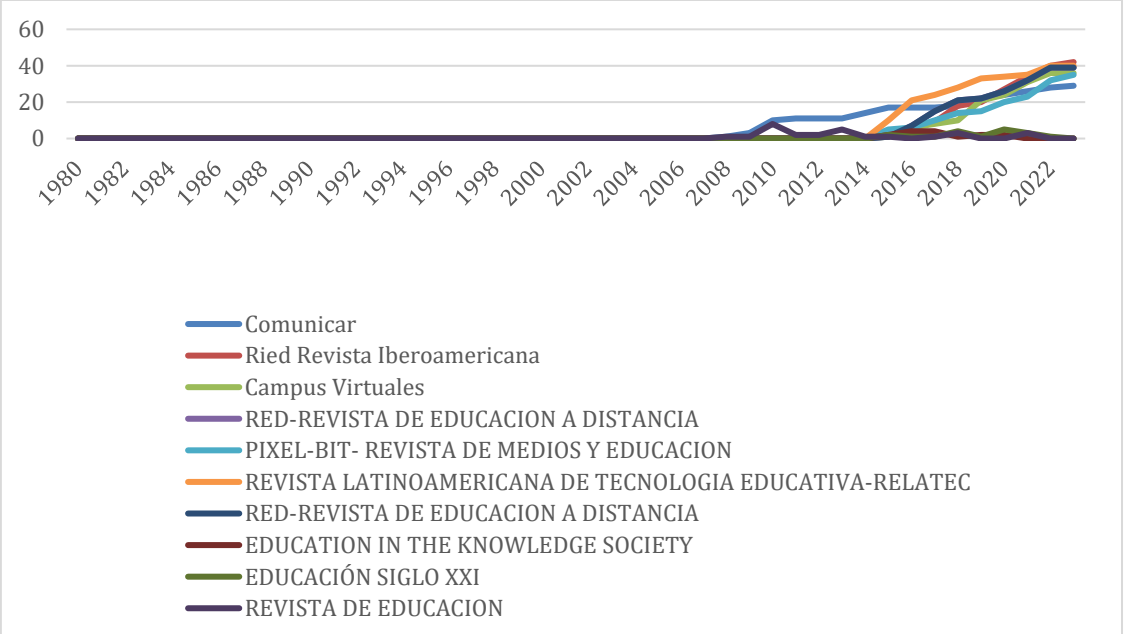
Sources	h _index	g_index	TC	NP
COMUNICAR	17	29	988	29
RIED-REVISTA IBEROAMERICANA DE EDUCACIÓN A DISTANCIA	13	19	457	42
CAMPUS VIRTUALES	8	14	229	36
EDUCACIÓN XX1	8	12	195	23
EDUCATION IN THE KNOWLEDGE SOCIETY	7	15	244	15
PIXEL-BIT REVISTA DE MEDIOS Y EDUCACIÓN	7	10	140	35

RED-REVISTA DE EDUCACIÓN A DISTANCIA	7	11	187	39
REVISTA DE EDUCACIÓN	7	13	190	28
REVISTA LATIONAMERICANA DE TECNOLOGÍA EDUCATIVA-RELATEC	7	7	106	40

Source: Own elaboration, 2024.

The growth curve for the most relevant sources (Figure 5) shows an upward trend in practically all cases, suggesting that this is an area of interest and that a significant increase in these topics can be expected in future scientific output.

Figure 5. Growth curve of the most relevant sources.



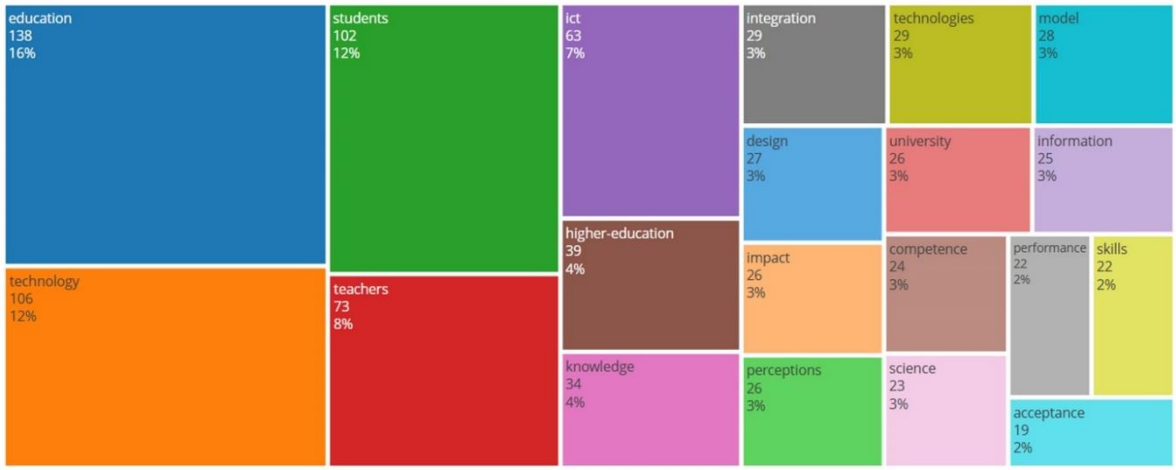
Source: Own elaboration, 2024.

3.3. Analysis of the conceptual structure

The analysis of the conceptual structure obtained by counting keywords provides very useful data for understanding the main themes and areas of discussion in the analyzed literature. The analysis of Keyword plus (ID=669) and the authors' Keywords (DE=3695) shows results that suggest a wide variety of topics or areas of focus in scientific production, together with a wide range of key terms used by the authors to describe their research.

Figure 6 shows the 20 main keywords (ID) with frequency indices above 2%. The following words stand out in the central core: “Education” (n=138, 16%), “technology” (n=106, 12%) “Student” (n=102, 12%), ‘Teachers’ (n=73.8%), and “Information and Communication Technology” (n=63.7%), which are basically the descriptors of the subject analyzed. These main keywords reflect the main characteristics of the conversation. The rest of the concepts present, although less frequent, allow us to access conceptual elements developed from the theme, highlighting the interest in the integration of attitudes, skills, and competencies in pedagogical models, preferably in higher education.

Figure 6. Conceptual structural analysis of keywords (ID).



Source: Own elaboration, 2024.

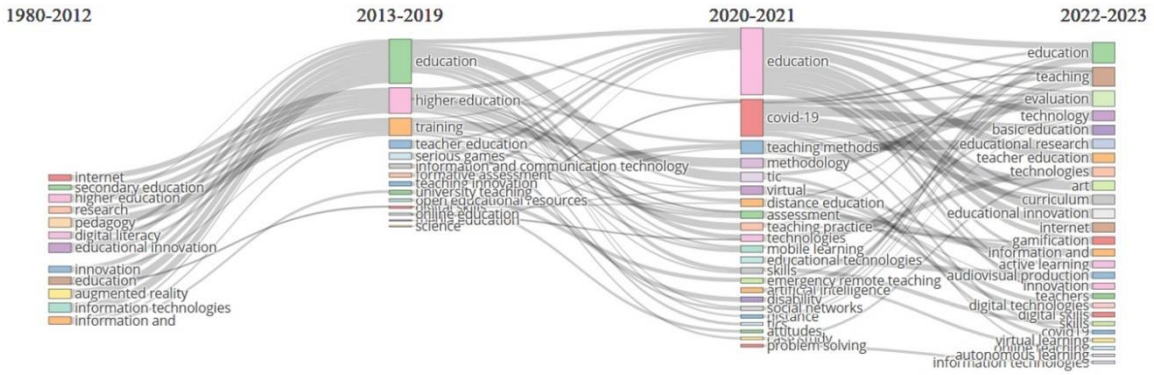
Based on the author's keywords (DE=3695), we can analyze the thematic evolution by constructing a map (Figure 7) that shows the change and development of the key concepts used in scientific literature. According to the transformation, the map is divided into four stages. The first stage (NP=107) covers the period from 1980 to 2012 and focuses on very generic concepts related to innovation and pedagogy in secondary education, highlighting words such as internet, augmented reality, and digitization.

In the second period, from 2013 to 2019 (NP=1040), there is a significant change in the educational level, as secondary education ceases to be relevant and there is greater development in favor of higher education. Innovation in education and pedagogy evolves towards training, education, and skills in teaching and assessment.

The third period was strongly influenced by the COVID health crisis, from 2020 to 2021. During this time frame, the keywords clearly respond to the need to cover online teaching and find virtual methodologies that would allow teaching to develop in the new situation. Thus, the most representative words were: education, COVID-19, online teaching methods, distance learning.

The last period, from 2022 to 2023, shows a wider variety of terms, marking a clear evolution of the term education towards concepts such as assessment, technology, curriculum, research, and active learning. Methodology loses strength, evolving towards digital skills, virtual learning, and online teaching.

Figure 7. Map of thematic evolution.



Source: Own elaboration, 2024.

3.4. Analysis of the social structure

This section analyzes data relating to the total number of authors and articles using h-index, g-index, and m-index metrics in order to determine the productivity, impact, and collaboration of each author and the influence of the most representative researchers (Table 5).

Nineteen percent of the analysis corpus is single-authored (single-authored docs = 373). This suggests that there is a considerably small proportion of researchers working independently or, in other words, there is a significant amount of collaboration between authors in the scientific output analyzed. The analysis yields a total of 4,239 authors, with an average of 2.62 co-authors per document.

The author Cabero-Almenara from the University of Seville stands out in scientific production and impact, with an h-index of 13 and a g-index of 18, indicating that he has published at least 13 articles with at least 13 citations each and has received a total of 18 citations. His m-index is approximately 0.93, suggesting that most of his articles are the result of collaborations. His total number of citations is 367.

His works focus on virtual assessment and the creation of teaching materials and methods in the virtual environment.

Barroso-Osuna, second in the ranking, also from the University of Seville and a collaborator of Professor Cabero-Almenara, has an h-index of 7 and a g-index of 8. His m-index is 0.875, suggesting a high level of collaboration in his research. The third author in the ranking, Professor López-Belmonte from the University of Granada, with an m-index of 1, shows a high level of collaboration between authors; in his case, all of his scientific output is co-authored.

Table 5. List of authors with the greatest impact.

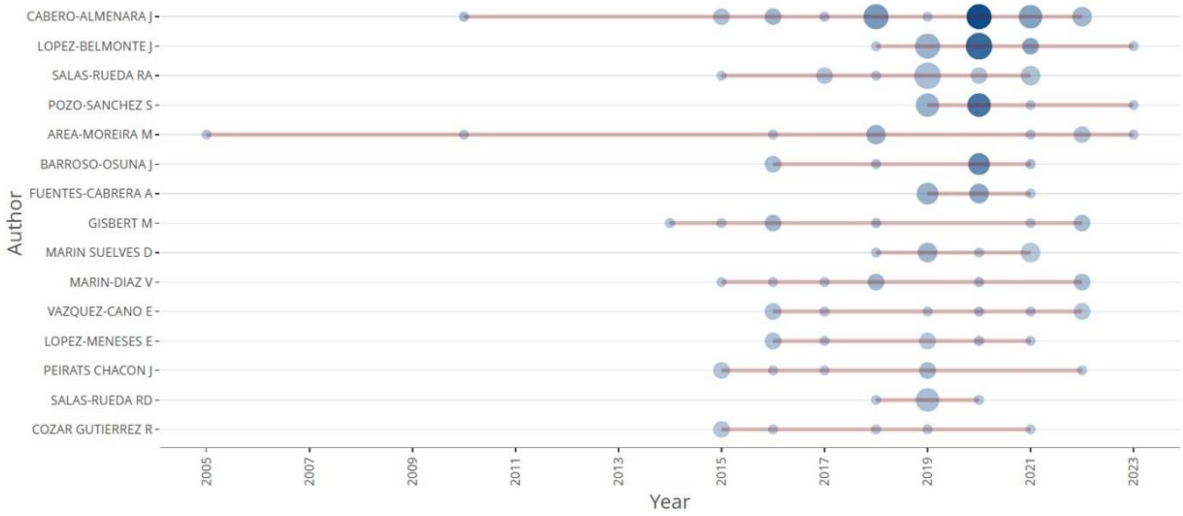
Element	h _index	g_index	M_index	TC	NP	PY_start
Cabero-Almenara J.	13	18	0,92857143	367	27	2010
Barroso-Osuna J.	7	8	0,875	124	8	2016
López Belmonte J.	6	13	1	176	17	2018
Gisbert M.	5	8	0,5	69	8	2014
Marin Díaz V.	5	7	0,55555556	52	8	2015
Pozo Sánchez S.	5	11	1	127	12	2019
Vázquez Alonso A.	5	6	0,41666667	79	6	2012
Area-Moreira M.	4	7	0,0,21052632	50	10	2005
Esteve-Mon F.	4	4	0,5	58	4	2016
Fuentes-Cabrera A.	4	8	0,8	70	8	2019
García-Carmona A.	4	5	0,25	74	5	2008
Llorente-Cejudo C.	4	5	0,57142857	115	5	2017
López-Meneses E.	4	5	0,5	33	7	2016
López-Nuñez Ja.	4	6	0,8	81	6	2019
Manassero-Mas M.	4	5	0,33333333	67	5	2012
Palacios-Rodríguez A.	4	5	1	78	5	2020

Vázquez-Cano E.	4	5	0,5	33	8	2016
Adell J.	3	3	0,5	64	3	2018
Calderon-Garrido D.	3	4	0,6	35	4	2019

Source: Own elaboration, 2024.

A temporal analysis of these authors' scientific output shows an increase between 2015 and 2022 (Figure 7).

Figure 7. Output of leading authors by number of articles and year.



Source: Own elaboration, 2024.

Co-authorships allow us to analyze the relationships between authors and the resulting cluster (Figure 8). Most of the nodes (authors) analyzed have a low score, suggesting that only a few authors serve as critical bridges in the collaboration network. One node (Cabero-Almenara) in particular stands out with a significantly higher value than the rest, indicating that the author is central in connecting different parts of the network. The analysis detected the nine most representative clusters, comprising a total of 31 authors. The average value of the Betweenness indicator, which reflects the overall contribution of nodes to intermediation in the network, is 3.14, which means that, on average, the nodes in the network act as intermediaries in approximately 3.14 shortest paths. The standard deviation (σ=8.52) according to the Betweenness indicator values indicates a high variability in the amount of intermediation performed by the nodes. We detected that some nodes have very low intermediation compared to the average. This variability suggests the presence of very disparate nodes in the network, which can be extremely influential or, conversely, have minimal intermediation. This variability can have significant implications in terms of the structure and dynamics of the network, as well as the way in which information or influence spreads through the network.

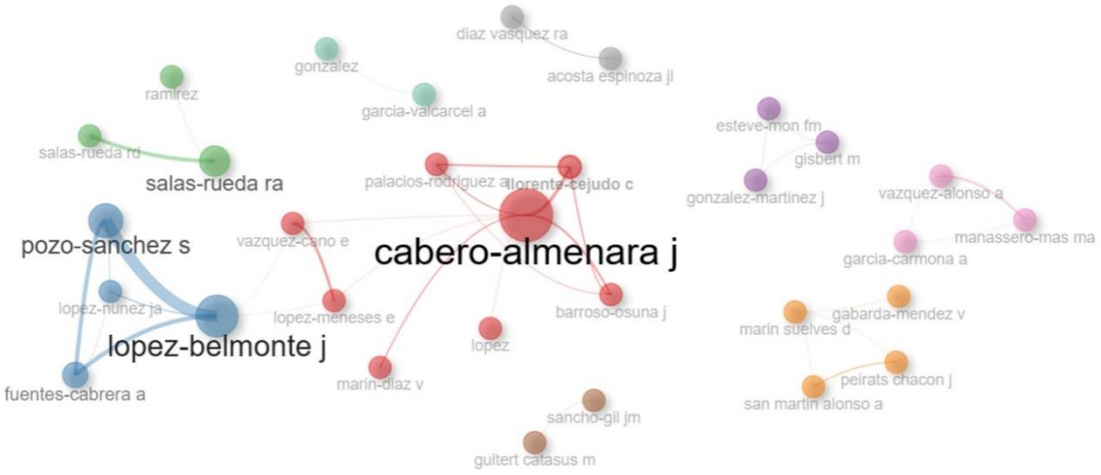
Cluster 1 with three dimensions (Salas Rueda R., Salas Rueda R. D., Ramírez Ortega, A.), according to the Closeness data (measure of centrality of a node in a graph), is positioned as the closest to the rest of the groups. Salas Rueda Ricardo (Closeness=0.5), PhD in new technology design and researcher at the Institute of Applied Sciences and Technologies at the Autonomous University of Mexico, is the most important node in terms of intermediation in this cluster and in relation to the rest of the nodes. Most of his publications are related to the University of Seville, with the central objective of analyzing pedagogical and technological models.

The second cluster is the largest, with eight dimensions, which implies extensive collaboration with extensive networks. In PageRank (a measure of the importance of a node in the network), Cabero-Almenara stands out, with high impact values in this cluster (PageRank = 0.0725778114318756), also yielding high results in intermediation (Betweenness = 37), which

indicates that he plays a very important role in communication and connectivity in the network and in the transfer of knowledge. The author acts as a key intermediary in the transfer of information and on the influence of the nodes. Together with the author López Belmonte (Betweenness= 25), Cabero-Almenara shows the highest values in intermediation, occupying a strategic position in the network, as both can act as "passage" nodes that facilitate communication between different authors in the network.

In relation to the average distance between nodes, the distribution shows ($\bar{x}$= 00.32) (σ=0.013), a wider variety in proximity values. Some authors are very centrally located, such as Salas Rueda (Closeness = 0.5), which means that they are close to all other nodes in the network, occupying a central role in the communication and connectivity of the network. Cluster 7 (González Martínez, Gisbert Cervera, and Esteve Mon), although it maintains very low data in relation to betweenness (Betweenness= 0), shows high closeness values identical to those of Cluster 1.

Figure 8. Collaboration network between authors.



Source: Own elaboration, 2024.

With regard to the centrality and position occupied by universities in the network, it should be noted that we found 12 clusters with a total of 43 universities (Figure 9). The top five clusters are made up solely of Spanish universities. The remaining seven clusters are single-dimensional, headed by the following countries: cluster 6: Argentina, cluster 7: Ecuador, cluster 8: Cuba, cluster 9: Ecuador, cluster 10: Chile, cluster 11: Colombia. This distribution indicates that international collaboration is practically non-existent.

With regard to betweenness between nodes, the distribution (σ=48.44) shows high variability, suggesting that there are nodes in the network that are outliers (nodes with values well above or well below the norm). Thus, we have nodes that are extremely influential and nodes that have minimal intermediation compared to most nodes in the network.

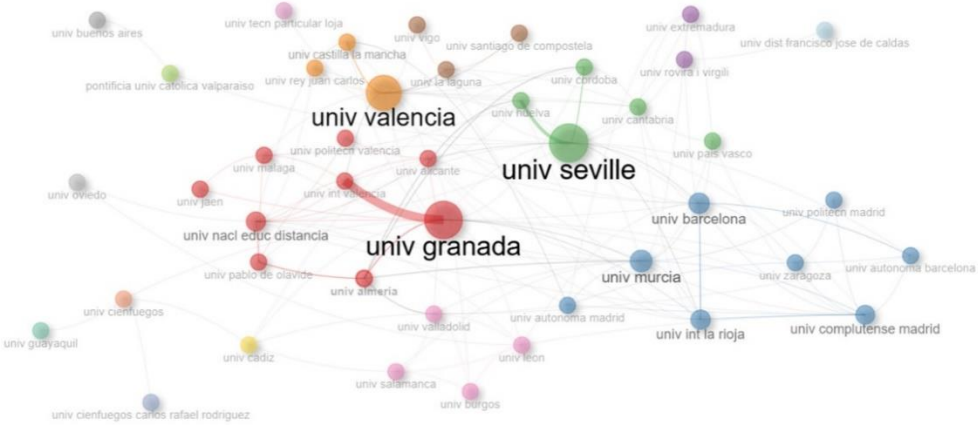
PageRank reveals that the nodes with the greatest influence in the network belong to three universities that stand out and play a very important role in communication, connectivity, and knowledge transfer: the University of Granada (PageRank=0.08), the University of Seville (PageRank=0.072), and the University of Valencia (PageRank=0.05). These three universities also occupy the top three places in the intermediation ranking, occupying identical positions: University of Granada (Betweenness=225.6), University of Seville (Betweenness=171.45), and University of Valencia (Betweenness=132.05). The three universities maintain a strategic position in the network, and acting as a "passage" to facilitate communication between different authors.

The average distance between the nodes in the distribution shows (σ=0.001, $\bar{x}$= 0.010) a high dispersion and a low average proximity, which translates into the lack of closeness between the

different clusters and, given their composition, we could add the peculiarity of finding low or no international collaboration.

Some of these universities are centrally located, such as the University of Granada (Closeness= 0.0147), the University of Seville (Closeness=0.0140), and the University of Barcelona (Closeness=0.013), which means they are very close to all the other nodes in the network, giving them a central role in the communication and connectivity of the network. Others, such as the University of Guayaquil, the University of Buenos Aires, and the University of Francisco de Caldas, occupy very peripheral positions, showing poor connectivity with the rest of the nodes in the network.

Figure 9. Collaboration network between universities.



Source: Own elaboration, 2024.

4. Conclusions

The high growth rate in scientific production on this topic may be related to increased interest in technological development and its application in teaching, which may lead to greater recognition and relevance, contributing to the development of new technologies and methodologies that can be extended to various spheres of scientific knowledge. Scientific output is mainly found in journals, with very little presence in book format. This can be explained by the rapid evolution of technology with constantly changing developments, which requires the use of a means of dissemination that can keep up with the latest advances, a circumstance that is more conducive to publications with faster cycles, such as journals. Growth in the period 2015-2022 can also be analyzed by the "Aneca Effect", defined as the anomaly in scientific publications in Spain, compared to the international pattern, which is reflected in the behavior of scientific production explained by the profound changes in our country's accreditation system (Masip, 2011), which took place from 2015 onwards. This fact would also explain the notable percentage difference between the different documentary genres, since after the accreditation reforms, authors are forced to publish in those collections that are a priority for the evaluation agency, concentrating production basically in high-impact journals.

The number of highly specialized journals on the subject is concentrated in two countries: Spain and Cuba, with Spain being the most specialized area in terms of the number of publications. The geographical distribution of scientific production in total publication counts is close to the results obtained with the Bradford matrix, with the three most relevant countries being Spain, Colombia, and Cuba.

Spain ranks as the leading country, with four journals among the top in the production ranking: Ried Revista Iberoamericana de Educación a Distancia, Relatec revista Latinoamericana de tecnología educativa, Red y Pixel-Bit Revista de medios y educación, and Comunicar, which is also first in the citation ranking. This result is consistent with the most relevant authors and the most

prestigious universities in the field: Julio Cabero-Almenara and Julio Barroso-Osuna, both collaborators at the University of Seville. Although there is a very high average level of collaborative work, there is almost no international collaboration between universities and researchers, nor is there any inter-university work. Thus, collaborations appear to be quite specialized, with a few authors who are clearly more central and possibly more active in collaboration or more cited by other authors. The fact that most authors have low intermediation and a low PageRank suggests that the network may be quite fragmented, with few authors acting as important connectors between more or less connected groups.

These low values, together with those presented in the connectivity indicator (closeness), suggest that there are few authors who stand out from the rest and who are significantly more important in the network.

This relevance, both in terms of source and authorship, may be in the process of change, as indicated by the results of the Bradford law analysis, which shows greater growth in peripheral sources, implying significant changes in the way scientific information is produced, distributed, and accessed. This variation could be explained by the variety of sources: a wider dispersion implies greater variety in the source of information, which could be the result of the specialization of certain related areas, or the emergence of specific areas. It is possible that technology and education, given their current relevance, have acquired significant importance, positioning themselves as a central subject with their own identity.

The conceptual structure shows a clear temporal distribution around three periods. The first period (1980/2012) focuses more on describing concepts such as “digitization” and “the internet.” It is an initial stage in which the description of and introduction to new terminology seems to constitute the essence of the literature. This first stage focuses on primary and secondary education, possibly driven by the inclusion of digital competence in the LOGSE educational reform. In a second stage (2013/2019), there is a clear tendency to direct research towards higher education, with very little presence of early childhood education, thus leaving a field of exploration uncovered. This contribution coincides with the analysis carried out by other authors who affirm that there are few texts that analyze the capabilities, competencies, and implications that the use of technology and digital media can have on the learning and development of young children (Kumpulainen et al., 2020).

Changes in curricula, such as the implementation of the EHEA educational reforms, may have been a determining factor in motivating scientific production on this subject at these educational levels, which is also reflected in the most developed topics focused on teacher training and the evaluation of methodologies.

The third period (2022/2023) is strongly influenced by the socio-health crisis, with a focus on online teaching and virtual learning. Concepts developed in these last two stages are worth highlighting: interest in the integration of attitudes, skills, and competencies into pedagogical models, preferably in higher education.

These results provide us with comprehensive information on the current state of scientific production in the area of technology and education in relation to social structure, with limited cooperation between universities and Spain's recognized prestige in terms of both authorship and publishing.

In terms of conceptual structure, it is worth noting the decline in research in the field of early childhood education, which should be an essential area of exploration.

In terms of temporal and geospatial analysis, the influence of regulations on scientific production is evident.

As a proposal for the development of future methodological designs using the Bibliometrix tool, we suggest a complementary content analysis of the most relevant aspects of publications, such as objectives and methodologies.

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