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A BIBLIOMETRIC ANALYSIS ABOUT THE SCIENTIFIC PRODUCTION IN HIGHER INSTITUTIONS

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ABSTRACT:
This work provides a general visualization of scientific production in higher institutions using bibliometric analysis. Firstly, detailed information on research articles on this topic was obtained from the Scopus database. Secondly, the data were analyzed using Excel to delete duplicates and extraction errors through the direct comparison and analysis of graphs related to the scientific production field's growth. Then, the bibliometric analysis was executed using the R-Studio tool. The results exposed those 2,281 documents published in 1,422 sources (journals, books, and others) elaborated by 7,561 authors with an annual growth rate of 9.80%, where the USA is the most important country for his times cited. Finally, a collaborative network of the countries and authors is provided according to the data analyzed from the documents related to scientific production in higher institutions to observe the most representative studies about this important field of the social and educational sciences.

INTRODUCTION

Scientific production is the direct result of research activity, in which products such as scientific research articles, books, book chapters, patents, utility models and technological products, architecture, and design, among others, are derived (Minciencias, 2021), occurring mainly in Educational Institutions such as universities in their research processes because they are creators and disseminators of knowledge. Piedra & Martínez, 2007; Arechavala, 2011; and Peralta, Solís, & Peralta, 2011 affirm that Higher Education Institutions (HEIs) are educational organizations that establish scientific production in their mission through publications that constitute the main component of scientific activity. It is also associated with the quality of the universities associated with the teaching processes and social projection, promoting the dissemination of the

knowledge generated in its investigative processes. On the other hand, García de Fanelli, 2014 and Bastidas & Benites, 2016 argue that scientific production in educational institutions has increased considerably in recent years thanks to its eminently social mission through the scientific productivity of researchers, whose research results constitute an instrument that improves academic quality in the HEIs globally. However, according to Ordorika & Rodríguez, 2010, another important aspect is the scientific production quality measured through indicators in the different rankings that establish institutional positioning and prestige, such as Times Higher Education in the global sphere is one of the most popular and influential. In the same way, according to Gómez & Gerena (2017) Scimago Institution Rankings, which weights the universities according to their publications using eight evaluation criteria. In addition, to O'Loughlin *et al.* (2015), Universities are classified according to their scientific productivity and academic indicators, which serve as the basis for financing and decision-making, contributing to the academic quality and reputation of the institutions.

According to Collins (1998); Rhoten & Parker (2005); Miller et al. (2008); Cummings & Kiesler (2008); and Rhoten (2011), interdisciplinary research and collaboration between researchers from many countries and regions of the world is becoming easier and growing, and therefore these are factors which influence the development of science, leading to the strengthening of mutual influences between countries. Then research taking place across many research centers and teams simultaneously lead to more successful distributed research collaboration. Ramírez (2015) exposed that the scientific production of university professors is obtained from three fundamental aspects, capacities, practices, and intentions. The first is the scientific research policies implemented by the institutions and the management in science and technology, as well as the generation of scientific development proposals, promoting and strengthening the transfer of knowledge and encouraging research in university classrooms. The second aspect refers to the levels of quality and degrees in the systematization of practices and experiences in the educational process, which allows for harmonizing and coordinating investigative skills, as well as expanding the scientific research production of teachers. The third aspect refers to innovation, contributions, and the teacher's capacities in the theoretical and practical development of the different areas of knowledge.

On the other hand, Mabe & Amin (2001); Díaz (2012); Kempener *et al.* (2010); and Rhoten (2011) state that there are trends and policies that positively or negatively affect the local and global dynamics of scientific production, depending on numerous factors both endogenous and exogenous in each country. Therefore, the impact of research and innovation policies and trends regarding research in each country may or may not encourage scientific development. According to Minciencias (2021), scientific production is defined as the direct results of research represented in seven types of products: research articles; scientific notes; research results books; book chapters research results; patents (of invention and utility model); Plant varieties, new animal breeds, and improved populations of livestock breeds (plant varieties, new animal breeds and improved populations of livestock breeds); and Products resulting from creation or research-creation (Works or ephemeral, permanent and procedural creation).

On the other hand, the present work aims to present a general visualization of scientific production in higher institutions using bibliometric analysis using the R-software and the information exported from the Scopus database considering the topic of scientific production in higher institutions is an important subject that it's in growth in the last years.

RESEARCH METHODOLOGY

Research on scientific production in HEIs is a field widely explored worldwide. In this sense, there has been a significant increase in publications on this subject in recent years, which is the methodology applied. For example, Pagani *et al.* (2015) proposed the development of 9 phases, starting with the selection and classification of scientific documents with the criteria: impact factor, number of citations, and year of publication, because it would not be possible to analyze all the research carried out. Following the methodology mentioned above, 2281 documents of different types and languages were found in the Scopus databases. These documents are based on a search equation that relates the articles through keywords ((scientific AND production AND (higher AND institutions OR universities)).

Data collection and Bibliometric Analysis (BA)

To Jin & Rousseau (2005), scientific metrics and bibliometric analyses are considered a point of reference by scientists to carry out new studies, discover new scientific trends through feedback within higher education institutions, and strengthen intellectual capital and scientific production through time. Pritchard (1969) considers bibliometrics as the application of statistical and mathematical methods to characterize written communication and identify the nature and development of scientific disciplines through the counting and analysis of said information. However, according to Ferrand *et al.* (2019), These bibliometric studies constitute parameters for assessing the scientific activity of the authors, research groups, journals, or countries, among other aspects, and finally allow the evaluation of scientific activity and its evolution over time.

In this way, the data was compiled in August of 2022 directly from the Scopus database related to scientific production in higher education institutions worldwide. The information was analyzed considering the methodology proposed in Fig. 1, which consists of three steps García-León *et al.* (2021); and García-León *et al.* (2021). First, the information about the scientific production (articles and books) was classified by areas and collaboration networks whose information was automatically provided by the Scopus database without using other software. This information was analyzed and discussed, considering theories of scientific production in higher education institutions and other publications. Notice that the scientific production analysis was developed considering only the information provided directly by the Scopus database about the authors and articles by areas and collaboration networks Aguillo (2012). However, the Scopus database was selected because it had the most high-impact documents, access facility, easy visualization of the data through the years, and graphical information actualized from the scientific production Visser *et al.* (2021).

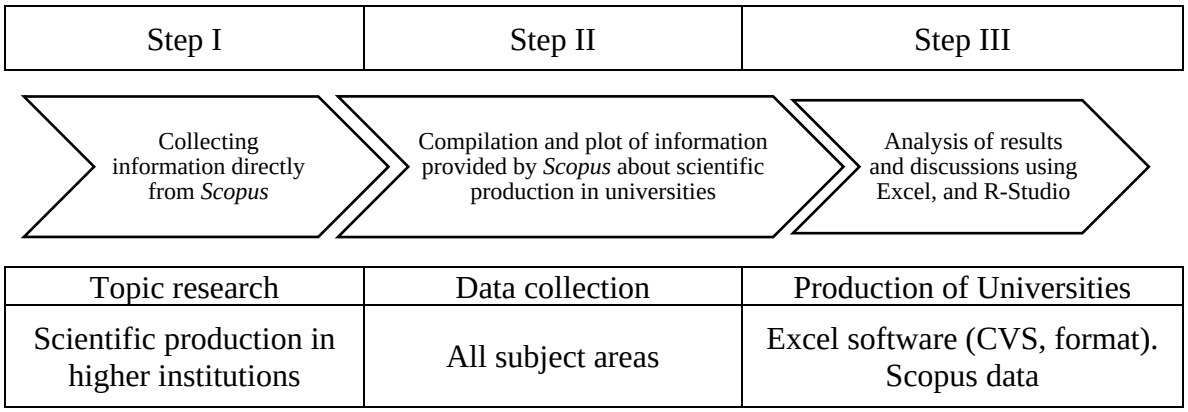

Figure 1. Methodology proposed.

Main hypotheses or implications

According to the literature review, the following hypotheses are proposed, H1: The most prominent countries are the most cited in the publications of scientific production in Higher Education Institutions. H2: Larger countries develop greater scientific collaboration in Higher Education Institutions.

RESULTS AND DISCUSSIONS

Bibliometric Analysis Results

Considering the steps proposed in Fig. 1, Table 1 summarizes the results obtained in the bibliometric analysis with their respective description. It is essential to mention that this selected topic has an annual growth rate of 9.80% from 1919 to 2022.

Table 1. Main information results about BA.

Description	**Results**
Timespan	1919:2022
Sources (Journals, Books, etc.)	1422
Documents	2281
Average citations per documents	10.25
Average citations per year per doc	1.249
References	75,737
Document types	
Article	1,572
Article in press	1
Book	19
Book chapter	97
Conference paper	360
Conference review	20

Editorial	14
Erratum	11
Letter	1
Note	8
Retracted	1
Review	175
Short survey	2
Document contents and Authors	
Keywords	8,766
Authors	7,561
Author Appearances	8,342
Authors of single-authored documents	392
Authors of multi-authored documents	7,169
Single-authored documents	429
Documents per Author	0.302
Collaboration Index	3.87

Source: Authors.

The results of the bibliometric analysis of the published studies of the scientific production in higher education institutions in *Scopus* in the period 1919 to 2022 are described in Table 4. Notice that around 2,281 documents were obtained in different languages, distributed in 1572 articles, 360 conference documents, 175 review documents, 97 book chapters, 20 conference reviews, and 19 books mainly, with the participation of 7,561 authors, of which 392 are sole authors and 7,169 co-authors, with 75,737 references, an average of citations per document of 10.25 and a collaboration index of 3.87, in these documents 8766 keywords related to this topic of the study were used.

Types of documents and areas

Fig. 2 shows the percentage of types of published documents. It is evident that 69% belong to 1572 articles, followed by 16% of 360 conference papers, 8% of review articles, and the remaining 7% are books and chapters, notes to the editor, and others. It is important to mention that related to the BA, 750 documents belong to a relationship between different areas such as social sciences, 341 to engineering, 339 to medicine, 278 to agriculture and biology, 271 to computer science, and other areas less frequently such as environmental sciences, business, arts and humanities, economics, materials science, decision sciences, which incorporate the importance of scientific production in different areas of knowledge.

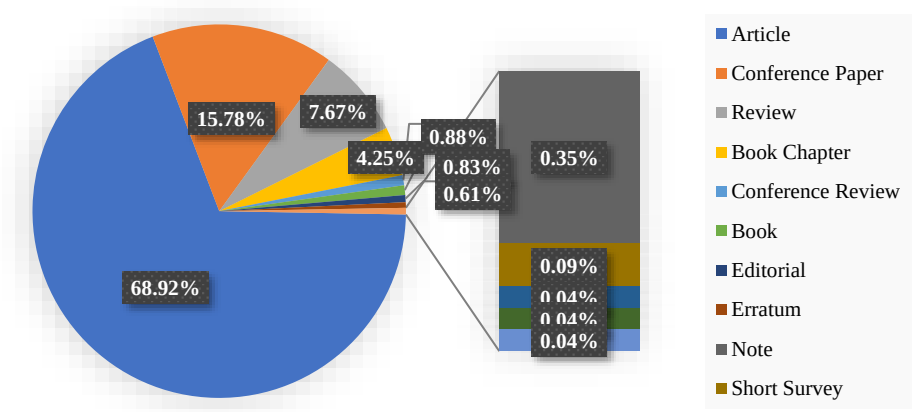

Figure 2. Percentage of types of documents analyzed. **Source:** Authors.

Annual scientific production

Fig. 3 shows the evolution of scientific production over the years. With an annual growth rate of 9.80%, this evolution is more significant in recent years because during the period 1919 to 2000, 121 publications were obtained, which represents only 5%, as in the period 2001. As of 2010, 436 documents were published, which represents 19%, constituting low levels of research on this topic of study; while in the years 2011 to 2011, there were 1,595 publications, which constitutes 70%, in the same way as August 2022, there are 129 publications, which represents 49% of the previous year and 6% of the total. In conclusion, in a century of research on scientific production in higher education institutions, 2,281 documents were published in Scopus from 1919, the year when the first document was published in Scopus, until 2010, which is very low considering that it only provides the 24%, while 76% corresponds to the last 12 years, which means that in recent years there has been a significant increase in publications on this topic of the study shows the evolution of scientific production over the years.

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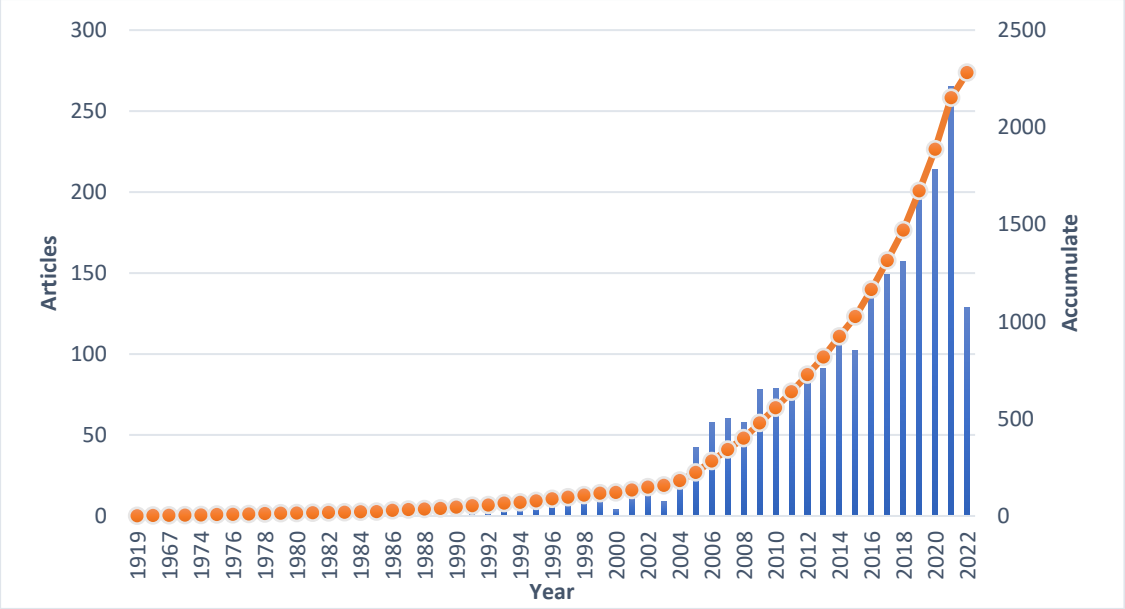


Figure 3. Evolution of scientific production. **Source:** Authors.

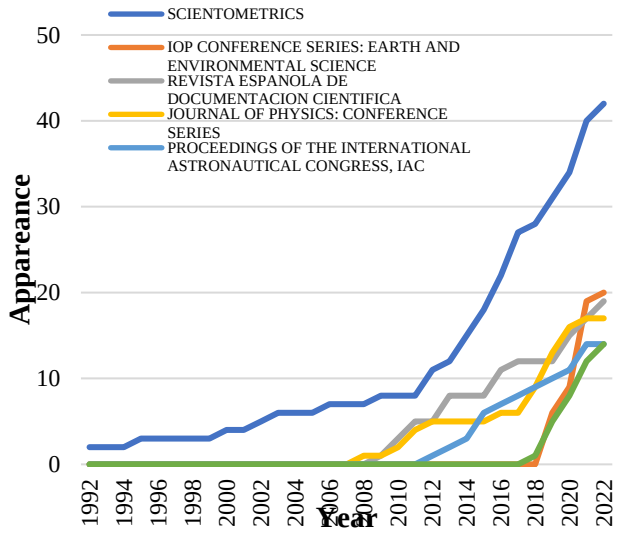
Most relevant sources.

Table 2 shows the most important journals resulting from the BA. It is important to mention that, from 1919 to 1992, the journals did not report citations related to the publications of each journal. It was until 1992 that the journals increased their visibility regarding the research and impact of the journals. It is essential to mention that the journal Scientometrics ranks first with 42 publications. The second corresponds to the IOP conference series: earth and environmental science with 20, the third to Revista Española de documentation scientific, the fourth to journal of physics: conference series, and then Proceedings of the international astronautical congress IAC, Sustainability (Switzerland) with 14 publications each. These important journals and conferences provide many publications from global scientific production research in higher education institutions.

Table 2. Most important journals and evolution over the years.

Sources	Articles	Plot of the behavior across years
Scientometrics	42	
IOP conference series: earth and environmental science	20	
Revista espanola de documentacion cientifica	19	
Journal of physics: conference series	17	
Proceedings of the international	14	

astronautical congress iac	
Sustainability (Switzerland)	14
Acta horticulturae	13
Espacios	13
Journal of cleaner production	13
Profesional de la informacion	13
Acm international conference proceeding series	12
Asian journal of plant sciences	12
E3s web of conferences	12
Plos one	12
Proceedings of spie - the international society for optical engineering	12
Gornyi zhurnal	11
Nongye gongcheng xuebao/transactions of the chinese society of agricultural engineering	11
Lecture notes in networks and systems	10
Pakistan journal of biological sciences	10
Universidad y sociedad	10



Source: Authors.

Authors, countries, and Institutions.

Table 3 shows the 10 most important authors from the BA, considering the number of citations among the documents analyzed. The most influential author is Karpov, A. O., of Bauman Moscow State Technical University, Moscow, Russian Federation, with 10 citations; Also important are the authors Andreyko, Sergey S., and Tashkinov, Anatoliy A., who belong to Perm National Research Polytechnic University, Perm, Russian Federation with 8 citations each; the authors Ferligoj, Anuška; Matveeva, Nataliya from HSE University, Moscow, Russian Federation with 7 citations each, among others.

Table 3. Top 10 local cited authors.

Author	Local citations
Karpov AO	10
Andreyko SS	8
Tashkinov AA	8
Ferligoj A	7
Matveeva N	7
Liberalesso AM	6
Schinaider AD	6
Talamini E	6
Afsarmanesh H	5
Bunin ZV	5

Source: Authors.

Table 4 shows the results of the 10 most important authors considering the BA's number of publications, citations, and appearances. Note that the authors with the highest number of publications are not always the most cited, as in the case of Bordons, María, a researcher in Social Sciences, Computer Science, Mathematics, and Medicine who belongs to the Higher Council for Scientific Research, Madrid, Spain; researchers Buela-Casal, Gualberto; Guillen-Riquelme, Alejandro; Quevedo-Blasco, Raúl researchers in Psychology, Medicine, Social Sciences and Arts and Humanities at the University of Granada, Spain are the most cited with an h_index of 6, with 8, 6, 7 and 6 publications in Scopus.

Similarly, Aleixandre-Benavent, Rafael; Alonso Arroyo, Adolfo researchers in Medicine, Social Sciences, Computer Science, and Mathematics at the University of Valencia, Spain; Pacheco-Mendoza, Josmel, a researcher in Medicine, Social Sciences, and Biochemistry at the San Ignacio de Loyola University, Lima, Peru; Powell, Justin J.W., Social Sciences, Health Professions, and Business researcher at the University of Luxembourg, Esch-Sur-Alzette, Luxembourg; and Wang, Quan a researcher in Medicine, Biochemistry, Genetics, and Molecular Biology at The First Bethune Hospital of Jilin University, Changchun, China h_index of 5 with 9, 9, 8, 5 and 6 publications respectively. It was also evidenced that the total number of citations is higher in researchers with h_index 6 except Alonso Arroyo, Adolfo, who has 118 and belongs to h_index 5, in the same way of the ten authors mentioned above, seven began to publish from the year 2011. This behavior indicates that the largest publication on scientific production in higher education institutions is recent.

Table 4. Top authors based on publications, citations, and appearances.

Autors	h_index	Total Citations	Number of Publications	PY_start
Bordons M	6	302	8	1992
Buela-Casal G	6	102	6	2011
Guillén-Riquelme A	6	112	7	2011

Quevedo-Blasco R	6	102	6	2011
Aleixandre-Benavent R	5	92	9	2008
Alonso-Arroyo A	5	118	9	2008
Pacheco-Mendoza J	5	97	8	2016
Powell JJW	5	61	5	2017
Wang Q	5	83	6	2011
Abad-Segura E	4	103	5	2020

From the aforementioned authors, Powell & Dusdal, (2017) carried out an important study on the growth of scientific production in France, Germany, and the United Kingdom by measuring the growth of articles indexed in the Thomson Reuters Science Citation Index Expanded (SCIE), showing that the organizational forms vary in their contributions, with a representation of the universities of almost half, but it increases in France; ultra-stable in Germany and growing in the UK, this research was carried out in highly productive countries according to Fig. 11. However, Fig. 4 shows the main authors and their products over the years, consistent with Fig.3 from the year 2011, in *Scopus* the number of publications of the scientific production in higher education institutions increases, especially in the years from 2019 to 2022 is visualized with larger ovals.

Notice that, authors such as Pacheco-Mendoza, Josmel from the Universidad San Ignacio de Loyola in Peru stand out in these publications; Von Kampen, Peter of Universität Bremen, Germany; the researchers Aleixandre-Benavent, Rafael; Alonso Arroyo, Adolfo from the University of Valencia, Spain; Bordons, María of the Higher Council for Scientific Research, Madrid, Spain; among others, who agree with the most important authors based on publications, citations, and appearances of Table 4.

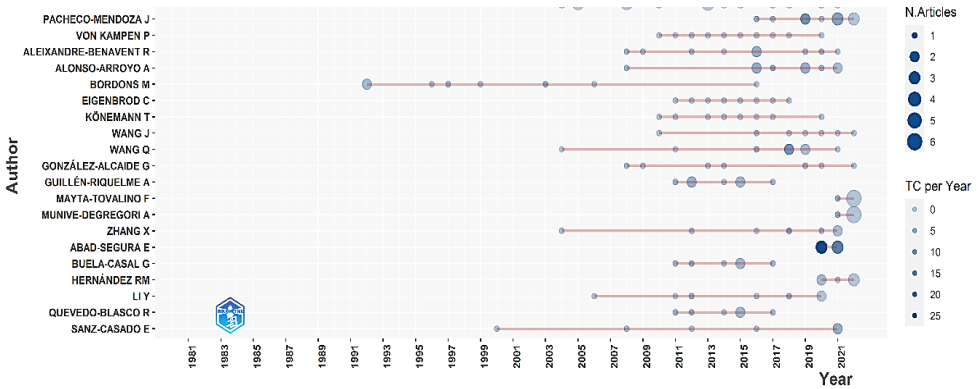


Figure 4. Main authors and their production over the years. **Source:** Authors.

Fig. 5 shows the most relevant institutions in some articles. It is observed that among the most important institutions, according to the level of publications on scientific production in higher education institutions in Scopus in the period 1919 to 2022, there are universities in Peru, such as the case of Universidad San

Ignacio de Loyola with 34 publications, and the Universidad Nacional Mayor de San Marcos with 30 documents published in first and third place respectively.

The contribution of Spanish universities is also important, such as the universities of Granada with 20, Almería and Valencia with 18 publications each in fourth, eighth and ninth place respectively; In Brazil, there is the University of São Paulo with 22 and the Federal University of Santa Catarina with 17 publications located in the fifth and tenth position; In the same way, there is the important participation of the Tehran University of Medical Sciences with 33 in second place, and the University College London with 19 published documents in seventh place.

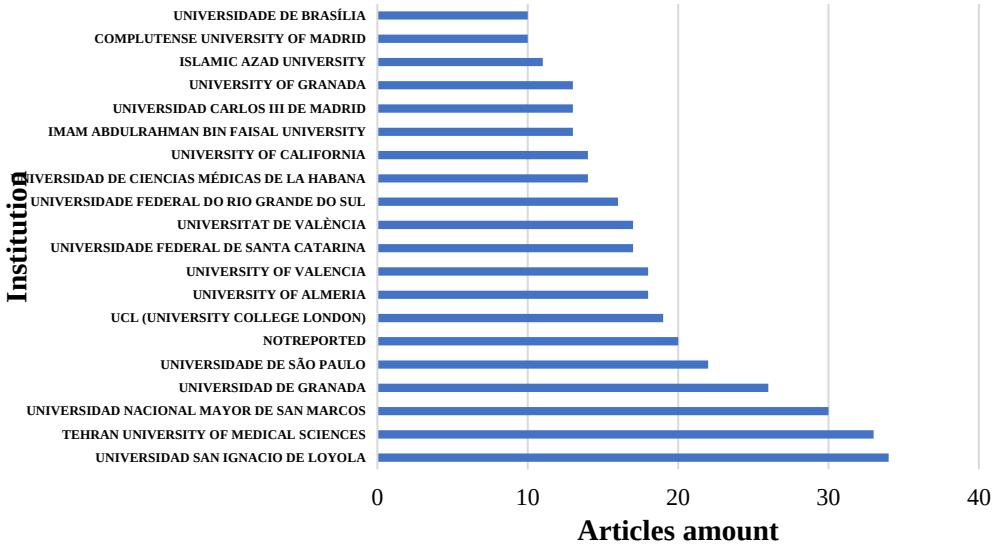


Figure 5. Most relevant institutions by the number of articles. **Source:** Authors.

Fig. 6 shows the 20 most cited countries in publications of scientific production in higher education institutions in *Scopus* from 1919 to August 2022, visualizing that the United States is the most important worldwide with 3315 publications. In addition, there are other countries from the American continent, such as Brazil with 982, Canada with 613, Mexico with 271, and Colombia with 176 published documents; There is also significant participation of European countries such as Spain with 2631 publications, United Kingdom with 2376, Italy with 836, Germany with 828, France with 662, the Netherlands with 566, Denmark with 553, Poland with 257, Switzerland with 243 and Belgium, with 181; from the Asian continent is China with 954 publications, Iran with 558, and Korea with 216; and from the African continent is South Africa with 247 and Tanzania with 246 published documents.

According to the above, research on this topic of study is very representative of the largest countries in the world with the most significant scientific development, with a great representation of American and European countries. Also, Fig. 6 confirms hypothesis H1, which establishes that the most significant countries are the most cited in the publications of scientific production in Higher Education Institutions because the United States and a large part of the countries that belong to the European Union are the most cited in the publications of the scientific production in these institutions according to *Scopus*.

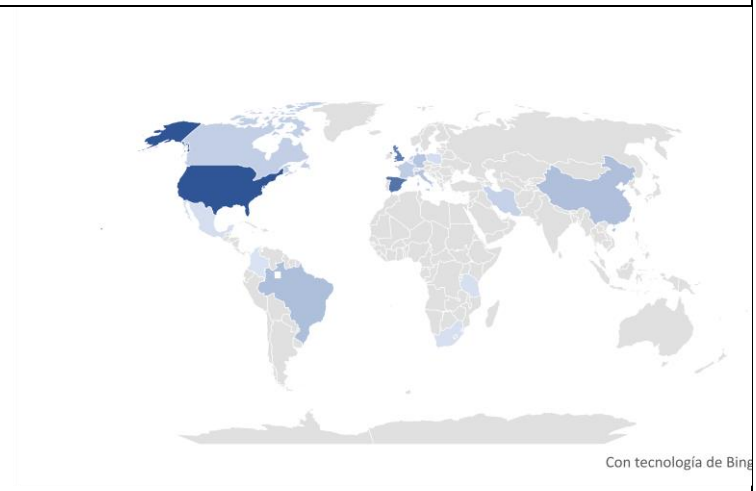
Country	Times cited	Plot of world map
USA	3,315	
Spain	2,631	
United Kingdom	2,376	
Brazil	982	
China	954	
Italy	836	
Germany	828	
France	662	
Canada	613	
Netherlands	566	
Iran	558	
Denmark	553	
Mexico	271	
Poland	257	
South Africa	247	
Tanzania	246	
Switzerland	243	
Korea	216	
Belgium	181	
Colombia	176	

Figure 6. Most cited countries. **Source:** Authors.

Considering studies carried out in the background and the review of the literature, evidently important studies have been carried out, such as those reported by Salmerón & Manzano, (2018), which carried out a bibliometric analysis of the scientific production in Scopus on virtual laboratories, in which they evaluated indicators such as time, types of publications and countries, keywords, institutions, main journals and proceedings that publish on this topic. It was shown that, according to the average number of citations per published article, the first three institutions are from the USA: Massachusetts Institute of Technology (MIT), University of Washington, and Carnegie Mellon University. In another bibliometric study, Buela, *et al.* (2017) evaluated the research activity in Spanish public universities in databases from 2014. It was shown that, in the world ranking, the universities with the highest production are the universities of Barcelona, Madrid Complutense, and Granada. In productivity, the top positions are dominated by Pompeu Fabra, the Autonomous University of Barcelona, and Pablo de Olavide universities. Finally, Guerrero, *et al.* (2019) analyzed the behavior of the use of the ontological model of the scientific production of active researchers, multidisciplinary publications, citation quartiles, and researchers who work in collaboration with others attached to the

Autonomous University of Yucatan (Mexico), which serve to know the academic level and technology of a teacher, a research group and the institution.

Most relevant documents

Table 5 shows the most relevant documents, detailing the number of local and global citations. Related to the most important study of Archambault, *et al.* (2009), a comparison was made of the bibliometric statistics obtained from *Scopus*. Ellegaard & Wallin, (2015) bibliometrically analyzed the academic production of publications in the Information and Library Science (ILS) category on the Web of Science. Mayta-Tovalino, *et al.* (2021) developed a bibliometric analysis of the national academic production of all dental schools in Peru in *Scopus* from the Peruvian University Law 30220 in 2014. Fernández & Baker, (2017) evaluated the scientific production in the United States through the research capacity of higher education institutions based on the advancement of American science in the 21st century; Finally, Jones, *et al.* 2008) found that elite universities play a dominant role in changing virtually every field of science, engineering, and the social sciences, through the rapid growth of impactful multi-university collaborations. Considering the above and the other related studies in Table 5. These investigations, in general, examine the publications of scientific production in higher education institutions in the period 1919 and August 2022 through Scopus, making bibliometric statistical comparisons, in the most representative countries, in some areas of knowledge, magazines, and institutions, with the use of databases such as Scopus and Web of Science, which is the most predominant.

Table 5. Most relevant documents.

Document	DOI	Year	Local Citation	Global Citation
Archambault, 2009, J Am Soc Inf Sci Technol	10.1002/asi.21062	2009	10	342
Ellegaard O, 2015, Scientometrics	10.1007/s11192-015-1645-z	2015	8	522
Mayta-Tovalino F, 2021, Int J Dent	10.1155/2021/5510209	2021	7	9
Fernandez F, 2017, Int Perspect Educ Soc	10.1108/S1479-367920170000033006	2017	6	10
Jones Bf, 2008, Science	10.1126/science.1158357	2008	6	431

Powell Jjw, 2017, Int Perspect Educ Soc	10.1108/S1479-367920170000033005	2017	5	18
Bressan RA, 2005, Braz J Med Biol Res	10.1590/S0100-879X2005000500001	2005	5	33
Gregorio-Chaviano O, 2020, Biomedica	10.7705/biomedica.5571	2020	5	20
Yao Q, 2014, Health Res Policy Syst	10.1186/1478-4505-12-26	2014	4	56
García-García P, 2005, Eur J Obstet Gynecol Reprod Biol	10.1016/j.ejogrb.2005.06.039	2005	4	28
Belmonte-Urenã LJ, 2020, Hortscience	10.21273/HORTSCI14533-19	2020	4	30
Garrido-Cardenas JA, 2018, Algal Res	10.1016/j.algal.2018.08.005	2018	3	103
POWELL JJW, 2017, INT PERSPECT EDUC SOC-A	10.1108/S1479-367920170000033003	2017	3	8
Bueno-Aguilera F, 2016, Med Oral Patol Oral Cir Bucal	10.4317/medoral.20756	2016	3	11
Buela-Casal G, 2015, Psicothema	10.7334/psicothema2015.140	2015	3	11
Siamian H, 2013, Acta Inform Med	10.5455/aim.2013.21.113-115	2013	3	12
Gazni A, 2012, J Am	10.1002/asi.21688	2012	3	214

Soc Inf Sci Technol				
Abramo G, 2009, Technovation	10.1016/j.technovation.2008.11.003	2009	3	121
Ugolini D, 2007, Carcinogenesis	10.1093/carcin/bgm129	2007	3	53
Bordons M, 2003, Scientometrics	10.1023/A:1024181400646	2003	3	95

Source: Authors.

Considering the result of the documents analyzed in the BA, Table 6 shows the most cited local papers, where the impact factor of scientific journals was analyzed, and the dissemination of knowledge through the citation index (h-Index) as an instrument to evaluate researchers, journals, and research groups. In general, the dynamics of science and research worldwide have been analyzed.

Table 6. Most Cited Local Documents.

Cited References	Citations
Van Eck, N.J., Waltman, L., Software Survey: Vosviewer, A Computer Program For Bibliometric Mapping (2010) Scientometrics, 84, Pp. 523-538	23
Mongeon, P., Paul-Hus, A., The Journal Coverage Of Web Of Science And Scopus: A Comparative Analysis (2016) Scientometrics, 106 (1), Pp. 213-228	14
King, D.A., The Scientific Impact Of Nations (2004) Nature, 430, Pp. 311-316	13
Katz, J.S., Martin, B.R., What Is Research Collaboration? (1997) Research Policy, 26 (1), Pp. 1-18	12
Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M., (1994) The New Production Of Knowledge: The Dynamics Of Science And Research In Contemporary Societies, London: Sage	8
Buela-Casal, G., Bermúdez, M.P., Sierra, J.C., Quevedo-Blasco, R., Castro, A., Ranking De 2008 Productividad En Investigación De Las Universidades Públicas Españolas (2009) Psicothema, 21, Pp. 304-312	7
Buela-Casal, G., Sierra, J.C., Criterios, indicadores y estándares para la acreditación de profesores titulares y catedráticos de universidad (2007) Psicothema, 19, Pp. 537-551	7
Garfield, E., Citation Analysis As A Tool In Journal Evaluation (1972) Science, 178, Pp. 471-479	7

Lotka, A.J., The Frequency Distribution Of Scientific Productivity (1926) Journal Of The Washington Academy Of Sciences, 16 (12), Pp. 317-323	7
Buela-Casal, G., Bermúdez, M.P., Sierra, J.C., Quevedo-Blasco, R., Castro, A., Ranking De 2009 Investigación de las universidades públicas españolas (2010) Psicothema, 22, Pp. 171-179	6
Garfield, E., The History And Meaning Of The Journal Impact Factor (2006) Jama, 295, Pp. 90-93	6
May, R.M., The Scientific Wealth Of Nations (1997) Science, 275, Pp. 793-796	6
Aria, M., Cuccurullo, C., Bibliometrix: An R-Tool For Comprehensive Science Mapping Analysis (2017) Journal Of Informetrics, 11 (4), Pp. 959-975	5

Source: Authors.

Keywords analysis.

Considering that the search equation works with keywords, the most used keywords are shown below in Fig. 7. The most used keyword is Human with a frequency of 273 times, the second article with269 times, in the third bibliometric position used 243 times, in the fourth position are Humans used 181 times, in the fifth and sixth Publication and Publishing with a frequency of use of 130 times each, Medical Research and Educations used 98 and 97 times respectively. Also, the most used keywords in scientific production publications in higher education institutions are human resources, articles, bibliometric analysis, publications, countries, research, universities, and areas of knowledge according to the investigation objectives.

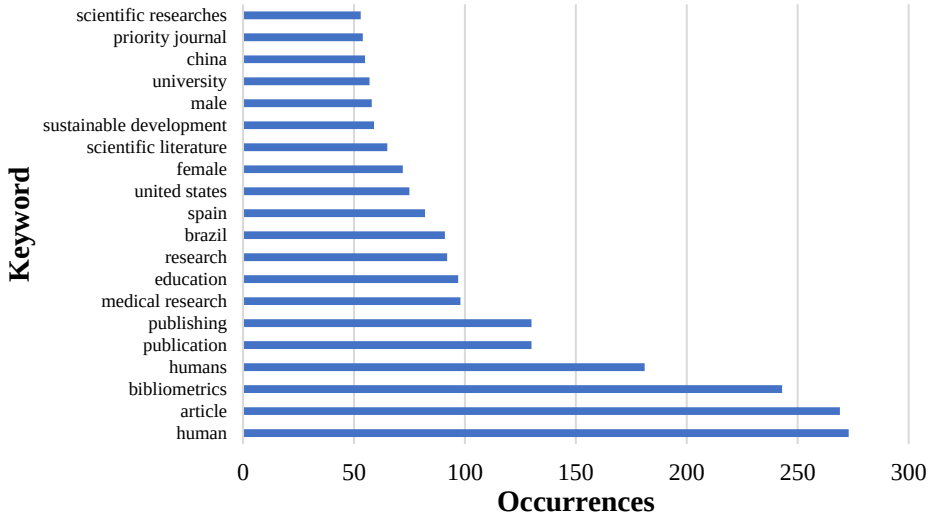


Figure 7. Most used keywords. **Source:** Authors.

Considering the keywords below, Fig. 8 shows the relationship between the coincidence between keywords and how areas of knowledge define them. In addition, the most used keyword is Human, and Humans in the fourth position are associated with the areas of history, human experiment, revision, Scopus,

among others, and the country of Brazil is dimensioned; Secondly, the word Article is related to publications, scientific literature, journal impact factor, databases, among others; the third keyword Bibliométrics, the fifth Publications and the sixth Publishing are related to productivity, priority journals, periodicals, international cooperation and Spain, Italy, China, and Europe are also displayed; the seventh keyword Medical Research is related to medicine, medical literature, and biomedical research among other areas of knowledge; The eighth most used keyword is Education, and it is related to the areas of research, teaching, universities, sustainable development, students, higher education institutions, among others.

In general, three large clusters are identified, the first in red at the top right with the keywords Human and Humans and the areas of knowledge with which they are related, the second in blue at the bottom with the keywords Article, Bibliometrics, Publications, Publishing Medical Research and its relationship with other areas, and the third one in green at the top left with the keywords Education, research, university, among others, indicates that the areas mentioned are the most important in the studies of scientific production at a global level in higher education institutions through Scopus in the period between 1919 and 2022.

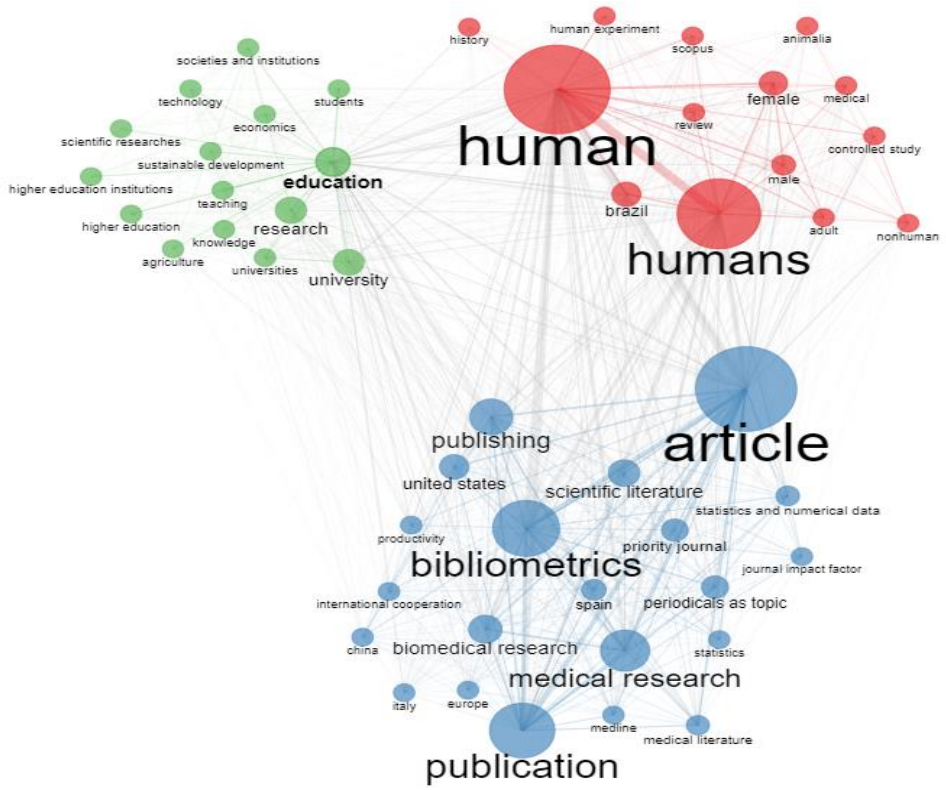


Figure 8. Network keyword. **Source:** Authors.

Fig. 9 shows the evolution of the theme for four periods of time from 1919 to 2022. The keywords through the periods evolved, so in the period 1919 to 2009, the words most used in the investigations were Societies and Institutions, Humans, Article, Priority Journal, and Review; when moving to the next period, 2010 to 2014, Article is maintained, and others such as Experiments, University,

Nonhuman, and Research appear; for the third period 2015 to 2018 Human reappears, University remains, Education, Microgravity and China appear for the first time; for the fourth period 2019 to 2020, china, human, and the United States and Scientific Researches appear for the first time; and in the last period 2021 to 2022 Human, United States, remains, and Publishing, Scopus, Higher Education, and Covid19 appear. According to the above, the keyword that is maintained in all periods is Human, which is consistent with Figs. 8 and 9, In the same way, it is visualized that the United States and China are the most productive countries in recent years. In addition, there are terms such as Scopus, publications, and higher education, which are essential to carry out bibliometric analyzes of scientific production in higher education institutions.

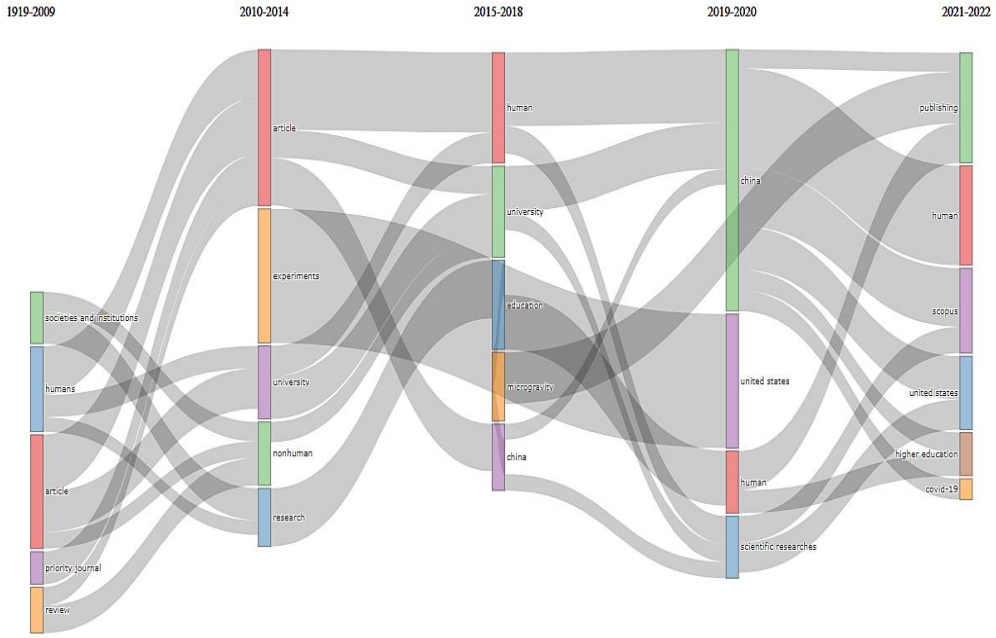


Figure 9. Thematic keyword evolution. **Source:** Authors.

Collaborative country networks

Table 7 below details the frequency of collaboration between countries. Collaboration in publications of scientific production in HEIs from 1919 to 2022 through Scopus occurs more frequently between large countries with greater scientific and technological advances and greater resources to finance research projects. In this sense, the collaboration between Spain and Portugal occurs with a frequency of 13, in second place Spain and Italy with a frequency of 12. In the same way, the collaboration between Brazil and Portugal, Germany and United Kingdom, Italy and the United Kingdom, the USA and the United Kingdom have a frequency of 11, and the collaboration between Brazil and USA and Spain and the United Kingdom is mainly also important. In general, it is observed that in the first 20 relationships of scientific collaboration, and coherence with Fig. 6, the European continent has eight collaborations between Spain, Portugal, Italy, Germany, the United Kingdom, and France.

In the same way, there is a collaboration between these countries with others in America, such as Brazil, the USA, Argentina, Mexico, and Colombia; It is

important to mention that the United States is the country with the most scientific collaboration according to the results obtained in this study. China's collaboration with the USA and Europe is also essential. The previously described represented in Table 7 confirms hypothesis H2, which establishes that the largest countries develop greater scientific collaboration in Higher Education Institutions because European countries have a more significant number of collaborations between them and with others such as the United States, China, and Canada, mainly, the collaboration of countries in the Americas with countries in the area and with others from the European Union and China is also evident.

Table 7. Collaboration WorldMap.

From	To	Frequency
Spain	Portugal	13
Spain	Italy	12
Brazil	Portugal	11
Germany	United Kingdom	11
Italy	United Kingdom	11
USA	United Kingdom	11
Brazil	USA	10
Spain	United Kingdom	10
Brazil	Spain	9
China	Germany	9
Italy	Germany	9
United Kingdom	France	9
USA	China	9
USA	Italy	9
Spain	Argentina	8
Spain	Mexico	8
Spain	USA	8
USA	Canada	8
Spain	Colombia	7
Germany	France	6
Italy	France	6
Spain	Chile	6
Spain	France	6
United Kingdom	Netherlands	6
USA	Germany	6
USA	Netherlands	6
Brazil	France	5
Brazil	United Kingdom	5
Germany	Sweden	5
Peru	Colombia	5
Peru	Cuba	5
Spain	Ecuador	5
Spain	Germany	5
United Kingdom	Switzerland	5
China	Italy	4

Germany	Canada	4
Germany	Netherlands	4
Spain	Cuba	4
Spain	Peru	4
Spain	Venezuela	4
United Kingdom	Portugal	4
United Kingdom	Sweden	4
USA	Colombia	4
USA	Switzerland	4
Brazil	Germany	3
Brazil	Italy	3
Chile	Argentina	3
China	Canada	3
China	Netherlands	3
China	United Kingdom	3

Source: Authors.

Networks

Fig. 10 shows a relational map between the authors, institutions, countries, and keywords. For example, in the relationship between a) Institution-Author-Country, it is seen that universities such as Almeria, Granada, Carlos III, and Valencia of Spain collaborate with authors from Brazil, Peru, China, Germany, Canada, and United Kingdom, among others; the Federal University of Santa Catarina in Brazil collaborates with European countries such as Spain, France, among others, while the National University of San Marcos and the San Ignacio de Loyola University collaborate with countries in the region such as Colombia and Cuba and Europe with Spain.

In the relationship between Institution-Author-Keyword, it is visualized in Fig. 11 that the universities of Almeria, Granada, Carlos III, and Valencia of Spain, in their publications of scientific production in institutions of higher education through the authors Alonso Arroyo, Adolfo; Aleixandre-Benavent, Rafael; Abad-Segura, Emilio; Buela-Casal, Gualberto; Guillén-Riquelme, Alejandro who have used the keywords Scientometrics, Psicotema, Natura, Sustentabity, science, among others. While researchers from the Federal University of Santa Catarina in Brazil, in a large proportion, publish publications where the keyword Scientometrics is used, and finally in the National University of San Marcos and the San Ignacio de Loyola University in Peru through researchers Pacheco-Mendoza, Josmel; Hernandez-Vasquez, Ronald; Gonzalez-Alcaide, Gregorio; Mayta–Tovalino, Frank; Munive-Degregori, Arnaldo who have used the keywords Scientometrics, Sustentabity and science among others.

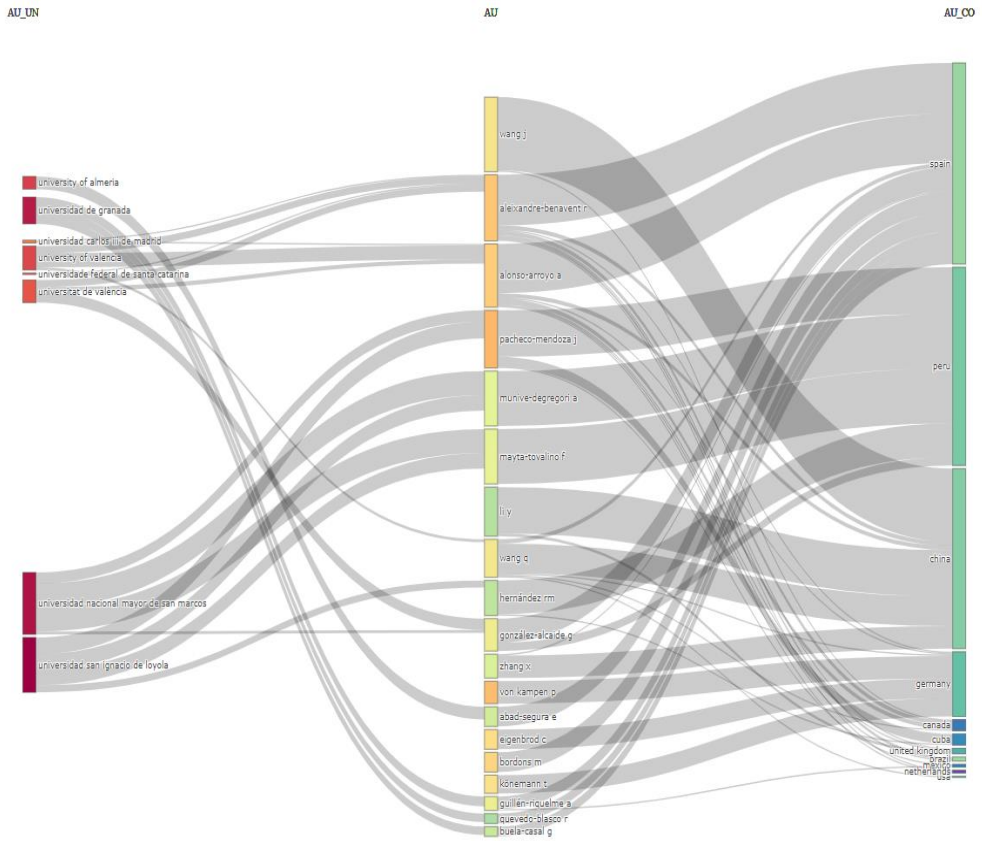


Figure 10. Relationship between Institution-Author-Country. **Source:** Authors.

Figure 11. Relationship between Institution-Author-Keyword. **Source:** Authors.

Fig. 12 shows the co-citation network among the authors analyzed in the BA. Note that the co-citation networks have different sizes and colors, the most important is red located at the bottom and the main author is Van Eck, Nees Jan (2010) linked to the Universiteit Leiden, Netherlands, which is linked to 11 researchers in this network, and his research areas are Computer Science, Mathematics, Social Sciences and Decision Sciences among others; the second network is orange located in the upper left part of the figure, its principal authors are Gibbons, Mike P.M. (1994), from Western University, London, Canada, and the Nowotny researcher, Hanna Franziska (2001), linked to the Klinikum der Universität München, Munich, Germany, are linked to four researchers in the co-citation network, their research areas they are Engineering, Environmental Science, Social Sciences, Biochemistry, Genetics and Molecular Biology, Medicine; the third network is green located in the central part of the figure and its principal researcher is Katz, Joshua S. (1997), belongs to International Flavors & Fragrances Inc. (IFF), Wilmington, United States, associated with four researchers in the network, and its performance is in the areas of Chemistry, Materials Science, Physics and Astronomy, Biochemistry, among others; the fourth co-citation network is colored blue located on the right side of the figure and its principal researcher is Hirsch, Jorge E. (2005) from the Department of Physics, San Diego, United States, associated with four researchers in the network, its areas of action are Physics and Astronomy, Materials Science, Engineering, Energy, among others; the fifth network is purple located in the central part of the figure, its principal researcher is Lotka, Alfred J. (1926) of Metropolitan Life Insurance Company, New York, United States, is part of this network with four other researchers, his research areas are Decision Sciences, Mathematics, Multidisciplinary, Social Sciences. Finally, the sixth co-citation network is brown, located in the upper right of the figure. Its principal investigator is Buela-Casal, Gualberto from the University of Granada, Spain, and his research areas are Psychology, Medicine, Social Sciences, and Neuroscience, among others.

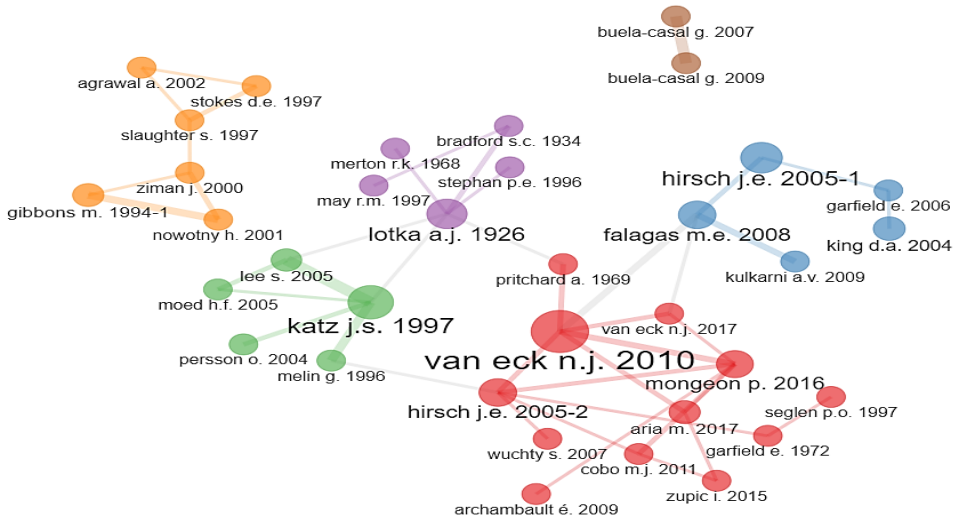


Figure 12. Co-citation network. **Source:** Authors.

However, Fig. 13 shows the different collaboration networks between the different authors. Note that each of the networks is identified by a different color, the most important being the blue one headed by von Kampen, Peter of the Universität Bremen, Bremen, Germany; there are also three collaboration networks of four researchers, the first in green on the left of the figure, the main researcher is Aleixandre-Benavent, Rafael from the University of Valencia, Spain; the second in red at the bottom of the figure, headed by Pacheco-Mendoza, Josmel from the San Ignacio de Loyola University, Lima, Peru; and a pink one on the left, led by Powell, Justin J.W., from University of Luxembourg, Esch-Sur-Alzette, Luxembourg. There is also a collaboration network of three researchers and six of 2 researchers.

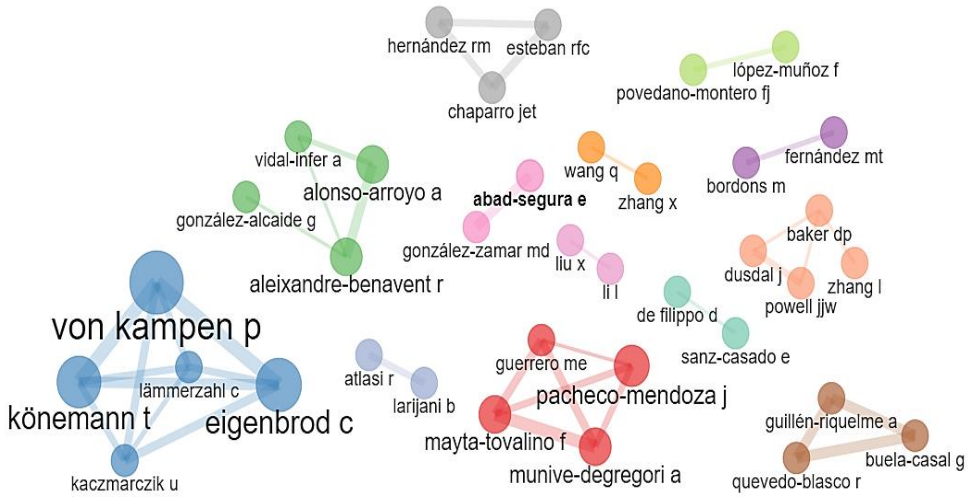


Figure 13. Collaboration network. **Source:** Authors.

CONCLUSIONS

To analyze scientific production, tools such as bibliometrics, databases, and some software are required to help analyze the existing literature on a research area, an institution, a country, or any other topic of study, depending on the objective Of the investigation, in this investigation, a bibliometric analysis was carried out at a general level that involved evaluating the level of publications through the history in the Scopus database, the countries, thematic areas, journals, institutions, and most representative authors in the publications of scientific production in IES in Scopus during the period 1919 to 2022, whose results showed that there are 2,281 documents published in different languages, distributed in 1,572 articles, 360 conference documents, 175 review documents, 97 book chapters, 20 conference reviews, and 19 books mainly, with the participation of 7,561 authors, of which 392 are from own authorship and 7,169 co-authors, with 75,737 references, an average number of citations per document of 10.25 and a collaboration index of 3.87, in these documents 8,766 keywords related to this topic of the study were used.

The most cited countries in publications of scientific production in higher education institutions in Scopus from 1919 to August 2022. As observed in the graph of Most Cited Countries, from the American continent are the States, Brazil, Canada, Mexico, and Colombia; from the European continent are Spain, United Kingdom, Italy, Germany, France, Netherlands, Denmark, Poland,

Switzerland, and Belgium; from the Asian continent is China, Iran, and Korea; and from the African continent South Africa and Tanzania, this indicates that research on this topic of study is very significant in the largest countries in the world with the most remarkable scientific development, with significant participation of mainly American and European countries. What was described above-confirmed hypothesis H1, which establishes that the most prominent countries are the most cited in the publications of scientific production in Higher Education Institutions because the United States and a large part of the countries that belong to the European Union are the most cited in the publications of scientific production in these institutions according to Scopus.

Regarding collaboration in publications of scientific production in HEIs, it occurs more frequently between large countries, with greater financing and scientific and technological advances to develop research processes. In this sense, the countries that collaborate more scientifically on this topic of study are Spain and Portugal, Spain and Italy, Brazil and Portugal, Germany and United Kingdom, Italy and the United Kingdom, the USA and the United Kingdom, Brazil and the USA. Spain and the United Kingdom, mainly. Considering the results of Collaboration WorldMap, the 20 most important collaboration relations scientifically, there are eight collaborations between countries of the European continent and five with other countries of America, especially with the United States, which is the country with the most scientific collaboration, and collaboration is also very important from China with the USA and Europe. Considering the results of Collaboration WorldMap, hypothesis H2 is confirmed, which establishes that the most prominent countries develop greater scientific collaboration in Higher Education Institutions because European countries have a greater number of collaborations between them and with others such as the United States, China, and Canada mainly, the collaboration of American countries with countries in the area and with others from the European Union and China is also evident.

The international scientific community has widely developed research on scientific production in HEIs at a general level due to the growing number of publications, mainly in large countries of the American continent, such as the United States, which is the most productive country in the European Union, as well as Asia and Africa in the period 1919 to July 2022 through Scopus, which have been developed in areas of knowledge such as Social Sciences, Medicine, Information, management and business, computing, education, and research mainly.

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