Bibliometric study on Quality Education

Estudio bibliométrico sobre la Educación de Calidad

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Abstract

Meeting the 17 sustainable development goals (SDG) declared in the 2030 Agenda is vital for our survival. Its fulfillment is incomplete without achieving an education for sustainable development. Previous bibliometric studies partially analyze the scientific production related to Quality Education, which does not allow full knowledge of its bibliometric behavior. For this reason, the objectives of this study are to analyze the scientific production related to SDG 04 during the 2017-2021 period and verify its level of integration with the other SDG. The Clarivate Analytics Incite tool was used to obtain the information and, to search for the documents and their metrics, the Web of Science Core Collection. 189,364 documents were identified from them, 141,372 were analyzed, distributed as follows: articles (135,476) and reviews (5,896). For the analysis and representation of the data, the VOSviewer tool was used, as well as Tornado and Sankey type diagrams. The results show that the terms with the highest co-occurrence were: COVID-19 (7,366), Mental health (5,903), Higher Education (5,659), Education (5,547), Gender (5,152), Sustainability (4,689), Food insecurity (4,394),

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Depression (3,444), and Health (3,338). The most influential sustainable development goals with Quality Education were 03 (Good Health and Well-being), 05 (Gender Equality) and 10 (Reduced Inequality). In relation to the countries with more than 1,000 published documents, the following stand out: the United States (46,937), the United Kingdom (14,611), Australia (11,659) and the People's Republic of China (10,307). The analysis of the scientific production justifies those efforts toward curricular sustainability and the integration of the sustainable development goals are still insufficient.

Keywords: bibliometrics, education, quality education, sustainability, statistical studies.

Resumen

El cumplimiento de los 17 objetivos de desarrollo sostenible (ODS) declarados en la Agenda 2030 es de vital importancia para nuestra supervivencia. Su cumplimiento es incompleto sin lograr una educación para el desarrollo sostenible. Estudios bibliométricos previos analizan parcialmente la producción científica relacionado con la *Educación de Calidad* lo cual no permite conocer totalmente su comportamiento bibliométrico. Por tal motivo, los objetivos de este estudio son analizar la producción científica relacionada con el ODS 04 durante el periodo 2017-2021 y comprobar su nivel de integración con los restantes ODS. Se utilizó la herramienta Incite de Clarivate Analytics para la obtención de la información y, para la búsqueda de los documentos y sus métricas, la *Web of Science Core Collection*. Se identificaron 189.364 documentos. De ellos, se analizaron 141.372 distribuidos de la siguiente manera: artículos (135.476) y revisiones (5.896). Para el análisis y representación de los datos se utilizó la herramienta VOSviewer así como diagramas de tipo Tornado y de Sankey. Los resultados muestran que los términos de mayor co-ocurrencia fueron: COVID-19 (7.366), Mental health (5.903), Higher Education (5.659), Education (5.547), Gender (5.152), Sustainability (4.689), Food insecurity (4.394), Depression (3444), y Health (3.338). Los objetivos de desarrollo sostenible de mayor influencia son los objetivos 03 (Salud y Bienestar), 05 (Igualdad de Géneros) y 10 (Reducción de las Desigualdades). En relación a los países con más de 1.000 documentos publicados, se destacan: Estados Unidos (46.937), Reino Unido (14.611), Australia (11.659) y República Popular China (10.307). El análisis de la producción científica justifica que aún son insuficientes los esfuerzos hacia la sostenibilidad curricular y la integración explícita de los objetivos de desarrollo sostenible.

Palabras clave: bibliometría, educación, educación de calidad, sostenibilidad, estudios estadísticos.

Introduction

The Sustainable Development Goals (SDG) are a current and future perspective of the construction of a sustainable world, with broad collaboration between economic, social, environmental, developmental, and sustainability factors (Sinakou et al., 2017). For this, the conception of a type of thinking that is systemic, complex, and global, about ecological and economic factors, or from a perspective of «planet», society, and «prosperity» is fundamental (McKenzie & Abdulkadri, 2018), through citizen action, participation, and empowerment.

To achieve the above, 17 SDG were defined (Figure I), as well as 169 inter-related goals, at least theoretically, to which all countries must contribute according to their policies and laws in accordance with the requirements from the Agenda 2030 (Armitage et al., 2020).

It has been reiterated in the scientific community that political strategies are marked by their isolated and particular characters, so that the achievement of the SDG is very challenging (García et al., 2020). One

FIGURE I. Objectives of sustainable development

Source: United Nations (2018a).

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of these objectives is 04 (Quality Education), which was conceived with a close relationship with the other SDG, by promoting the training and development of competences, attitudes, skills, values, and ways to understand and act in coherence with sustainable development.

In the official reports from the United Nations, it was declared that more than 250 million children are illiterate or do not have a way to access an educational institution (United Nations, 2019), underlining the need to eradicate or decrease the existing social, economic, and developmental divides in all countries.

Education is one of the main pillars of humanity, because, as a social and cultural process, it brings human beings closer to understanding, reflection, knowledge, and sustainable transformation for permanent learning, in coherence with society and nature (Estrada-Molina et al., 2022). The partial achievement of this objective is sometimes viewed from a general and quantitative perspective in the European Commission report "*Education and Training 2020*", and the annual report from the *"Organisation for Economic Co-operation and Development"* (OECD), which can be consulted (reports from the previous year) in the European Commission (2021) and the Organisation for Economic Co-Operation and Development (2021), respectively.

Quality education (SDG 04) is often studied from micro (family, friends, social relations –face-to-face or virtual), meso (society, social groups, school, education institutions, organizations, etc.), and macro (country level and its policies) perspectives. Thus the need for the social coherence and cohesion between the different socialization agents and the sustainable responsibility, aside from citizen awareness, political responsibility, access and the opportunities of quality education (Boeren, 2019; Estrada-Molina & Fuentes-Cancell, 2022). Even though many European Union (Pleśniarska, 2019), American (Corbett & Guilherme, 2021), Asian (Jermsittiparsert & Sriyakul, 2020), and African (Nafukho & Muyia, 2021) countries have made great advances on the implementation of SDG 04, it is still insufficient for meeting the indicators and goals established in this objective.

The studies conducted have demonstrated the interest of the scientific community to contribute, through social and scientific actions, towards the achievement of the SDG 04 objectives. However, how has academic production on SDG 04 behaved in the last five years? Have the publications on SDG 04 achieved integration with the other SDG? These questions, among other initial ones, motivated the performance of this bibliometric study.

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Bibliometric studies and systematic reviews about SDG 04

In the search performed (2017-2021) in the *Web of Science* (WoS) and Scopus, not many bibliometric studies and systematic reviews were found related with SDG 04. Of these (Table I), five were bibliometric studies, six were systematic reviews, and one a meta-analysis.

Most of them (Ferrer-Estévez & Chalmeta, 2021; Meschede, 2020; Prieto-Jiménez et al., 2021; Yeh et al., 2022) were characterized for conducting a bibliometric analysis of all the SDG, which in some sense, does not allow delving into a specific objective, although it establishes some approximations of quality with respect to their relationships. Other similar studies (Diksha & Chakravarty, 2022; Sweileh, 2020) have analyzed these objectives, but from the perspective of SDG 03, framing the strong relationships between this objective and Quality Education.

Only five studies (Crawford & Cifuentes-Faura, 2022; Palomino et al, 2022; Acosta-Castellanos et al, 2021; Avelar et al., 2019; García et al., 2020) have focused on SDG 04. The authors García et al (2020) performed a meta-analysis of 240 documents present in Scopus and WoS, through an initial extrapolation of academic production, without a co-analysis of keywords or a co-authorship analysis. Meanwhile, Avelar et al. (2019) performed a systematic review of 193 articles, and underlined, from the information collected from them, co-authorship networks, periodical publications, higher education institutions (HEI), and the most influential countries. However, as only a small sample was selected, their results did not provide a comprehensive perspective of SDG 04.

Palomino et al. (2022), in their qualitative systematic review (18 documents), analyzed the attitudes and competences of the educators for achieving education for sustainable development, although they did not analyze the indicators of academic production. Acosta-Castellanos et al. (2021) performed a systematic review with publications published between 1987 and 2021 related with education for sustainable development, associating it with SDG 04, but without identifying the indicators of academic production. Lastly, Crawford & Cifuentes-Faura (2022) initially analyzed the impact of COVID-19 on SDG 04, but did not provide an analysis of academic production.

The studies referenced show the interest of the academic community on SDG 04, its impact, trends, lines of research, and academic production. The studies published are not able to fully characterize the scientific production on this SDG.

TABLE I. Bibliometric studies and systematic review on SDG 04

Studies	Type of study	Sustainable development objectives	Source of data	Period
Yeh et al (2022)	Systematic review	All the SDG	WoS	2013-2022
Crawford & Cifuentes-Faura (2022)	Systematic review	ODS 04	PsycInfo, ERIC and Academic Search Ultimate	2020-2021
Diksha & Chakravarty (2022)	Bibliometric study	All the SDG centered on SDG 03	Scopus	2015-2019
Palomino et al (2022)	Systematic review	ODS 04	Scopus and WoS	
Ferrer-Estévez & Chalmeta (2021)	Systematic review	All the SDG	Scopus and WoS	2015-2020
Prieto-Jiménez et al (2021)	Bibliometric study	All the SDG	WoS	2015-2020
Acosta-Castellanos et al (2021)	Systematic review	SDG 04 and education for sustainable development	Science Direct, Scopus and ERIC	1987-2021
Sweileh (2020)	Bibliometric study	All the SDG centered on SDG 03	Scopus	2015-2019
Meschede (2020)	Bibliometric study	All the SDG	Scopus and Web of Science (WoS) Core Collection	2015-2019
García et al (2020)	Meta-analysis	ODS 04	Scopus and WoS	2015-2020
Avelar et al (2019)	Systematic review	ODS 04	WoS (Social Sciences Citation Index (SSCI) and the Emerging Sources Citation Index (ESCI))	2015-2018
Körfgen et al (2018)	Bibliometric study	All the SDG centered on scientific production in Austria	Publications in official university repositories	2013-2017

Source: Compiled by authors.

For this reason, this bibliometric study seeks to (1) identify the main sources of publications on SDG 04; (2) show and analyze the main sources of scientific collaboration from the perspective of a co-authorship network and a co-authorship map according to country; (3) identify the most-utilized terms; (4) determine the existing flow between SDG 04 and the other SDG; (5) determine the most frequent keywords, and (6) show,

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from the scientific production related with SDG 04, the universities with the greatest scientific production.

Method

The objectives of the present study were to analyze the scientific production related with SDG 04 during the 2017-2021 period, and to verify its level of integration with the remaining SDG. To achieve this objective, a bibliometric study was performed, as this type of study offers strategies, tools, methods, and techniques, to inquire and analyze the scientific production from different perspectives and aims (Mukherjee et al., 2022; Narin et al., 2016).

To achieve these objectives, the following research questions were posed:

- Question 1. What are the main sources of publications related with Quality Education?
- Question 2. What are the main sources of scientific collaboration?
- Question 3. What are the most utilized terms in publications related with SDG 04?
- Question 4. How does the proportion of the amount of flow observed between the SDG behave?
- Question 5. From the perspective of SDG 04, what are the top 20 universities with the greatest scientific production? With what other SDG is the Education research at these universities related with?

Sources of information and search strategy

To select the publications related with SDG 04, the filters provided by *Clarivate Analytics* in the platform InCites were utilized. This platform was selected, as it can determine if a publication indexed in the *Web of Science* (WoS) is related with one or many SDG (García, 2022).

The study was limited to publications related with SDG 04 present in the *Web of Science Core Collection* published between 2017 and

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2021. The system offered a result of 189,364 publications, twenty times that indicated in similar studies by Momete and Momete (2021); Prieto-Jiménez et al. (2021) and Salvia et al. (2019).

The document obtained was filtered to select the UT (*Accession Number*) of the publications, to afterwards download, from the *Web of Science Core Collection* the information on *author, title, source, abstract, keywords, reference cited and use, affiliations,* and*, document type*. From all of these documents (189,364), 141,372 were chosen, classified as: articles (135,476) and reviews (5,896).

When searching for the 141,372 documents in the *Web of Science Core Collection, v*arious cycles were utilized with a maximum of 36,000 manuscripts, utilizing the tags UT and OR for this. The research was conducted between the months of June and July, 2022.

Selection and representation of the information

The functionalities of VOSviewer were used to (1) analyze the scientific collaboration through a co-authorship analysis, and (2) to determine the most-utilized terms according to the author's keywords; for this, the co-occurrence of keywords were analyzed, as well as the networks created (Question 2). This *Software* was utilized, as it allows for the construction and visualization of academic networks for their posterior analysis and interpretation of the information provided (Orduña-Malea & Costas, 2021) and it also utilizes grouping techniques that are verified and useful for bibliometrics professionals (van Eck & Waltman, 2017).

To identify the authors with the greatest scientific production, those with more than 30 publications were selected. With respect to the collaboration between countries, those with more 1000 documents were selected. Lastly, in relation to the determination of the main keywords, those with more than 100 occurrences were selected (Question 3). In general, for the construction of bibliometric networks, analysis and measurement units were utilized, and for the identification of clusters, the visualization of similarities and grouping techniques from VOSviewer were utilized.

The Power-user add-in in Microsoft Excel was utilized to create a «tornado» diagram to represent 141,372 publications according to the main indexation categories of WoS (Question 4). This type of graphic was utilized, as it is a visualization alternative for representing similarities and differences associated to scientific production (Mitteer et al., 2018),

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making it possible to associate them with indexation categories, thus allowing for the comparison of the series of data obtained.

A «Sankey» flow diagram was utilized to represent the proportion of flow observed between the different SDG, from the perspective of SDG 04. For this, a 1x15 matrix was created according to the SDG (except for SDG 04 and 17, as no documents were found associated to this last objective). This diagram was utilized, as it allows representing and analyzing the relationships (flows) between the different starting and ending nodes (Lupton & Allwood, 2017). It has become one of the most utilized visualization resources for exploring association relationships (Chen et al., 2019).

To determine the scientific production of the top 20 universities (Question 5), the UTs of each publication associated to the SDG were filtered, and afterwards, the *Web of Science Core Collection* was explored to be able to consult the metrics it offers.

Lastly, to determine which 20 keywords were the most frequently used, from the perspective of SDG 04 and its value for each SDG, (1) the UTs from each publication associated to the SDG were filtered, and (2) the *Web of Science Core Collection* was explored, and (3) the necessary and sufficient information was exported for their analysis with VOSviewer.

It is important to highlight that the visualization of the information in different diagrams and networks, as well as the keywords, WoS categories, and university and country names, are shown in English, in accordance with the unified information provided by *Clarivate Analytics*.

Quality verification and strategy

To filter the UT for each SDG, the CONTAR.SI function from Microsoft Excel was utilized, which allowed for the identification and counting of these studies. The process was verified on three separate occasions by the authors.

Results

In the Incites (*WoS*) search, 189,364 publications were found in the 2017-2021 period. The main types of documents found were: *Article* (135,476), *Proceedings Paper* (28,915), *Editorial Material* (10,150), *Review* (5,896),

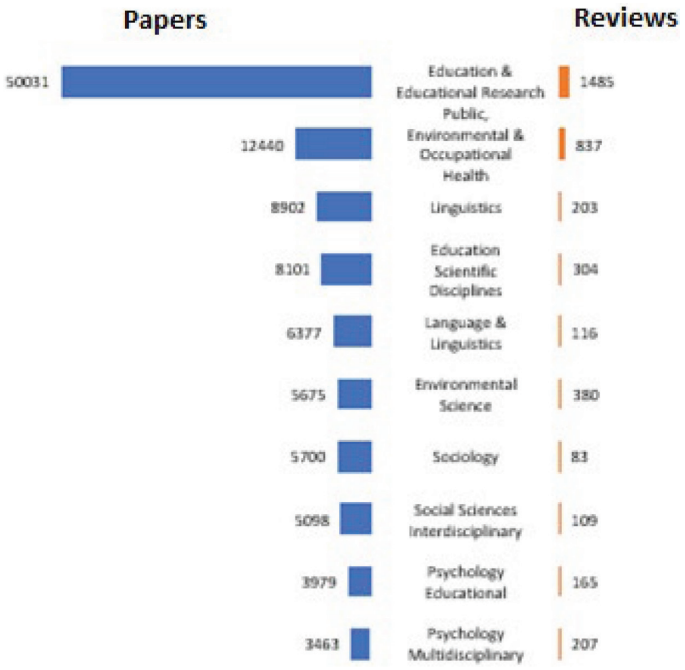
Letter (2,467), *Book Review* (2,315), and *Book Chapter* (1,446). In the analysis (Figure II), which only included articles and reviews (141,372), ten thematic categories of the WoS were underlined, with the following distribution: 2017 (23,581), 2018 (22,853), 2019 (26,768), 2020 (26,321), and 2021 (41,849).

The main categories were: *Education & Educational Research, Education, Scientific Disciplines, Public, Environmental & Occupational Health,* and *Linguistics*.

Question 1. What are the main sources of publications related with Quality Education?

In the analysis of the data, 16 journals stood out that grouped 500 articles (Table II). Of these, only seven were indexed in the category *Education & Educational Research* or *Education*.

FIGURE II. Distribution of the scientific production according to the top 10 indexation categories of the WoS



Source: Author created through the use of the Power-User add-in in Microsoft Excel.

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TABLE II. Main sources with the largest number of publications

Journals	**Documents**
Sustainability	2,302
International Journal of Environmental Research and Public Health	1,743
PLOS One	1,400
Frontiers in Psychology	1,219
Journal of Chemical Education	1,086
Teaching and Teacher Education	922
Computers & Education	686
BMC Public Health	680
Ciencia & Saude Coletiva	677
Education and Information Technologies	661
BMJ Open	608
International Journal of Science Education	602
Interactive Learning Environments	541
International Journal of Inclusive Education	535
Social Science & Medicine	503
Studies in Higher Education	503

Source: Compiled by authors.

Question 2. What are the main sources of scientific collaboration?

The authors with the greatest scientific production (more than 70 documents) were: Gwo-Jen Hwang (103) from the *National Taiwan University of Science and Technology*; Shervin Assari (93) from the Charles R. *Drew University of Medicine and Science*, Los Angeles; Karrie A. Shogren (80) from the *University of Kansas*; Chin-Chung Tsai (77) from the *National Taiwan Normal University*, and Tahmeed Ahmed (74) from the *University of Whashigton*.

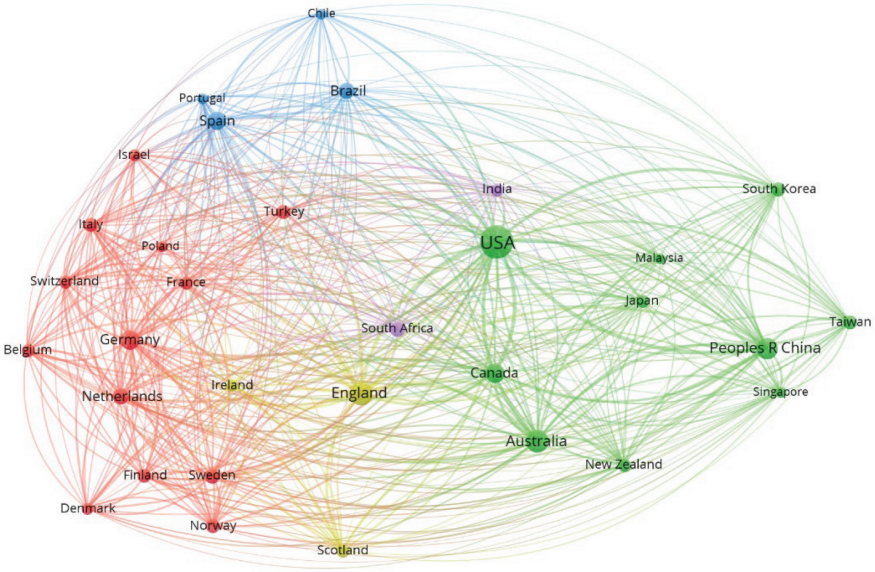
During the identification of collaboration networks, from co-authorship clusters, 279,155 were identified. Of these, 106 with more than 30 documents, and only 26 establishing inter-relations, with two author clusters underlined : (1) Wilfried Admiraal, Richard Mayer, Fred Paas, Katharina Scheiter, Tamara Van gog and Jeroen Van Merrienboer, and (2) Ching Sing Chai, Ronnel King, Yan Li, Jing Wang, Shanyong Wang, and Hongbiao Yin.

In the 141,372 documents analyzed, 199 countries were identified. With respect to the collaborations between the author's countries of origin (Figure III), 32 countries stood out with more than 1,000 published documents, principally: United States (46,937), United Kingdom (14,611), Australia (11,659), and the People's Republic of China (10,307), meanwhile, given the total number of strong links, these countries also stood out, with the addition of Germany and Canada. This measurement of 1,000 documents was utilized given that it was the smallest measurement suggested by VOSviewer associated to the relationship between clusters.

Question 3. What are the most utilized terms in publications related with SDG 04?

A total of 149,381 keywords were identified, of which 671 appeared in at least 100 publications (Figure IV). The terms with the highest co-occurrence (X≥1000) were: *Higher Education* (3,283), *Education* (2,569),

FIGURE III. Co-authorship map according to country



Source: Compiled by authors.

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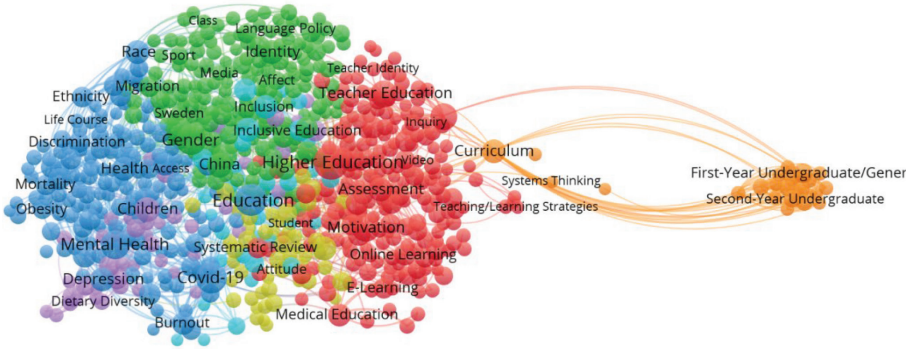
FIGURE IV. Network of keywords from the authors



Source: Compiled by authors.

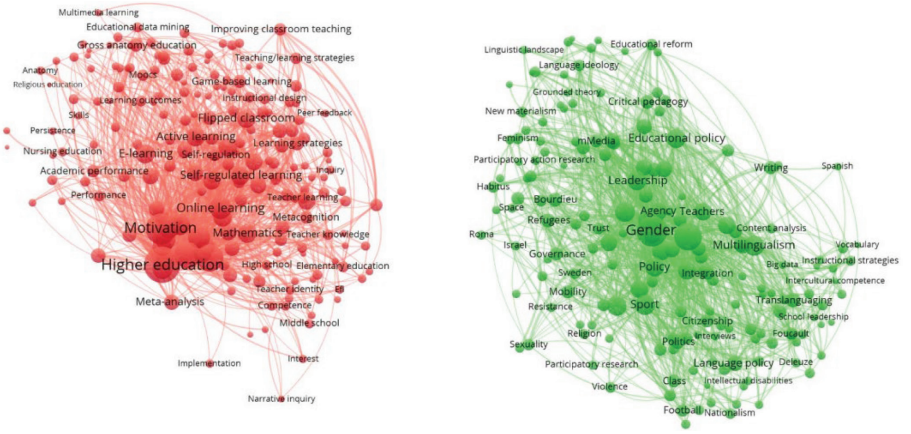
COVID-19 (2,257), *Gender* (2,025), *Mental Health* (1,692), *Motivation* (1,445), *Teacher Education* (1,373), *Professional Development* (1,336), and *Disability* (1,244). This measurement (X≥1000) was selected, as strong relationships between nodes were observed, according to the metadata obtained from the WoS.

In the analysis of keywords from the authors, seven sub-networks were identified. In the first (Figure V), the relationship/links between the terms *Higher Education* (2,208), *Motivation* (1,609), *Professional Development* (1,247) and *Teacher Education* (1,149) were underlined, that is, this the network in which the education phenomenon was studied from its structural education dimension, while in the second sub-network, the terms were *Gender* (1,076), *Identity* (888), and *Sport* (462), specific elements of cross-sectional education, related to education policies.

In the third sub-network (Figure VI), the following were underlined: *Mental Health* (2,124), *COVID-19* (2,036), *Depression* (1,536), *Education* (1,442), *Race* (1,152), and *Stress* (1,084), a health and psychological approach to the education phenomenon, while in the fourth, we found: *Sustainability* (323) and *Attitudes* (188), related to the works on education values.

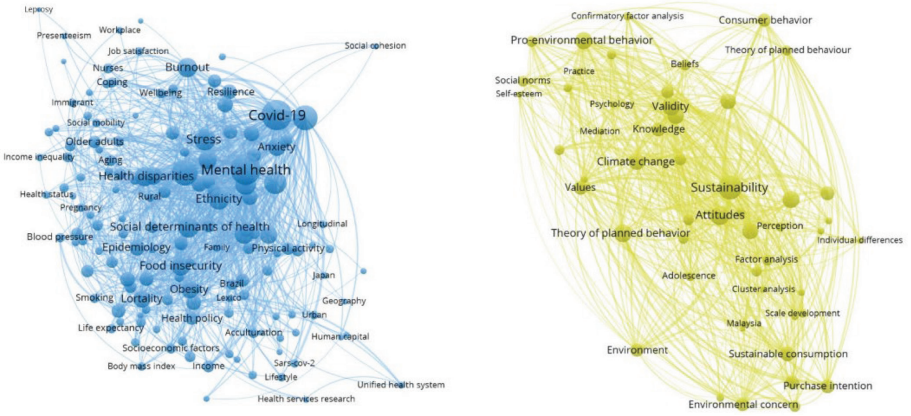
In the fifth sub-network (Figure VII), we found the keywords: *Stunting* (769), *Children* (477), *Malnutrition* (453), and *Nutrition* (459) which shows the importance of pediatrics and nutrition, through the dedication

FIGURE V. First and second sub-network (left to right)



Source: Compiled by authors.

FIGURE VI. Third and Fourth sub-network (left to right)



Source: Created by authors.

of an education dimension, while in the sixth sub-network, we found: *Inclusion* (586), *Diversity* (461), *Disability* (441) and *Inclusive Education* (339), where the Special Education articles would be found.

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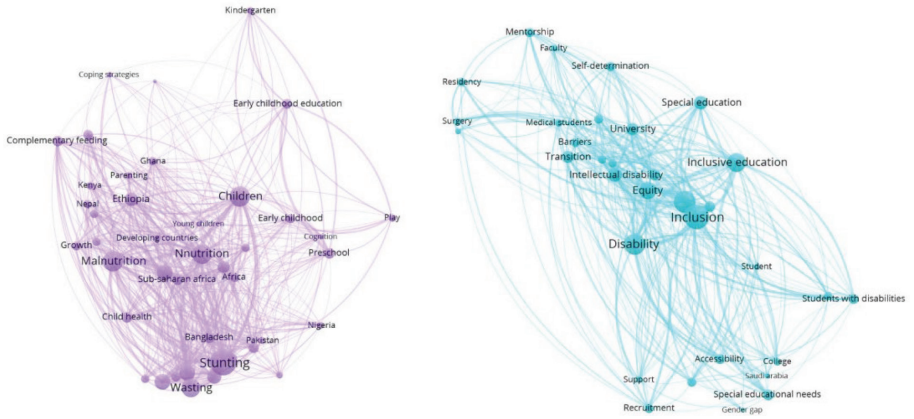
FIGURE VII. Fifth and Sixth sub-network (left to right)



Source: Compiled by authors.

Lastly, in the seventh sub-network (Figure VIII), the following keywords were found: *First-year Undergraduate-general* (1,375), *Second-year Undergraduates* (1,060), and *Laboratory Education* (887), that is, strongly applied works.

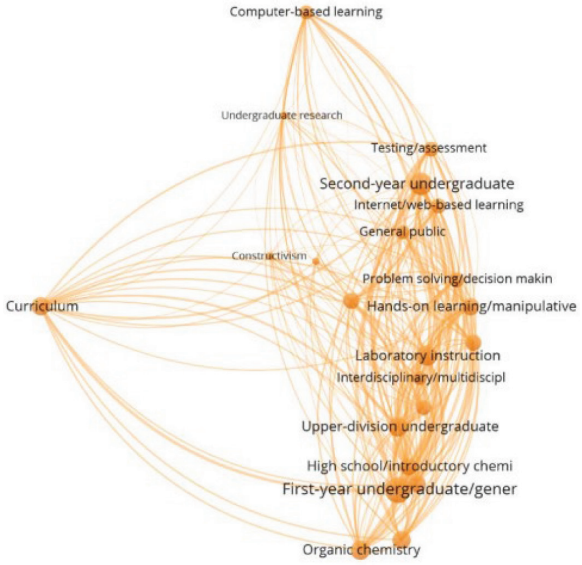
When analyzing the co-occurrence of keywords from the authors for each SDG (Table III), it was re-confirmed that SDG 03 and 05 had the greatest relationship with Quality Education. It is interesting (Table III) to underline that the keywords that coincided in the 16 SDG were: *COVID-19*, *Motivation, Children, Assessment, Sustainability y, Food insecurity*, while the ones with the strongest presence were: COVID-19 (7,366), *Mental Health* (5,903), *Higher Education* (5,659), *Education* (5,547), *Gender* (5,152), *Sustainability* (4,689), and *Food insecurity (*4,394).

Question 4. How does the proportion of the amount of flow observed between the SDG behave?

The analysis of the data allowed us to identify that none of the publications was associated with SDG 17 (Figure IX). The publications related with SDG 03 (Good Health and Well-being), 05 (Gender Equality), and 10 (Reduced Inequalities) had the strongest relationship with SDG 04.

Question 5. From the perspective of SDG 04, what are the top 20 universities with the greatest scientific production? With what other SDG is the Education research at these universities related with?

FIGURE VIII. Seventh sub-network



Source: Compiled by authors.

The main universities (Table IV) were located in the United States and the United Kingdom. Four universities were underlined among the 20 universities (*University of California System, University of London, University of Michigan, and Harvard University*) with respect to the scientific production on all of the SDG.

Discussion and Conclusions

The search provided a total of 189,364 publications from the 2017-2021 period, with 141,372 publications related with articles and reviews analyzed. The results confirm that the regions with the highest number of publications and highest impact (according to the citations of the documents) were the United States of America and European countries, in agreement with the results from Salvia et al (2019). And in general with the production at the global scale of the *Web of Science* database.

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TABLE III. Top 20 keywords by authors according to SDG 04

Keywords	ODS 01	ODS 02	ODS 03	ODS 04	ODS 05	ODS 06	ODS 07	ODS 08	ODS 09	ODS 10	ODS 11	ODS 12	ODS 13	ODS 14	ODS 15	ODS 16
COVID-19	219	255	1.387	2.257	1369	31	31	94	153	596	221	218	175	175	184	1
Higher Education	10	53	332	3.283	403	0	0	18	118	687	116	153	153	153	153	27
Education	41	91	767	2.569	742	7	7	20	70	687	92	104	106	106	107	31
Gender	95	128	824	2.025	1073	9	0	57	38	534	63	72	59	59	59	57
Mental health	92	85	1.535	1.690	1540	0	2	33	48	787	91	0	0	0	0	0
Motivation	7	202	152	1.445	186	20	20	4	20	24	13	71	55	55	55	4
Teacher education	0	51	0	1.373	254	0	0	1	13	72	12	28	29	29	29	2
Professional development	0	5	126	1.336	91	0	0	0	9	42	1	13	13	13	13	2
Disability	39	31	194	1.244	191	0	0	1	10	116	17	2	3	3	7	15
Children	316	347	740	996	553	5	5	11	3	96	30	42	43	43	45	14
Assessment	11	21	73	948	79	1	1	1	26	43	20	31	31	31	31	9
Depression	79	62	896	945	921	0	3	8	5	461	27	3	4	4	1	22
Race	18	17	424	924	583	0	0	2	8	495	33	12	12	12	12	28
Curriculum	2	14	119	921	162	0	0	1	24	69	29	34	35	35	35	3
Sustainability	50	504	125	895	102	20	20	31	184	60	163	622	622	632	632	27
Food insecurity	864	864	870	868	898	1	1	1	2	18	2	1	1	1	1	1
Diversity	5	12	403	965	462	0	4	5	12	168	13	16	17	16	17	9
Health	94	122	680	851	743	19	19	0	34	479	44	56	58	58	58	23
Inclusion	11	6	151	828	184	0	0	7	14	69	14	3	7	7	7	15
Social Capital	10	24	304	822	320	0	0	6	3	670	6	17	18	18	18	6

FIGURE IX. Distribution of the scientific production between the SDG

Source: Compiled by authors.

The scientific production obtained higher values in the years 2021, 2019, and 2020, which partially coincides with the bibliometric study by García et al (2020), which analyzed 98 documents from the WoS and 142 from Scopus, with the years of 2018 and 2019 having the highest production, according to their study. However, there was an agreement with respect to the sources of collaboration, the general distribution of the publications (Chin & Jacobsson, 2016), and that most of the publications belonged to the indexation categories *Education & Educational Research*, and *Education*.

The production of documents published, according to the SDG, showed that the strongest relationships with SDG 04 were found with SDG 03, 05, 10, and 02, partially coinciding with the general study on the SDG by Fonseca et al. (2020). These researchers performed a global

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TABLE IV. Top 20 universities with the highest number of publications on SDG 04

Universities	ODS 01	ODS 02	ODS 03	ODS 04	ODS 05	ODS 06	ODS 07	ODS 08	ODS 09	ODS 10	ODS 11	ODS 12	ODS 13	ODS 14	ODS 15	ODS 16
University of California System (10 campuses)	382	421	1.981	3.781	1.979	28	29	148	85	1311	218	113	130	131	133	159
University of London	452	481	1.580	3.468	1.431	19	20	138	150	999	254	103	124	125	137	231
University of Michigan	194	226	1.637	2.843	1.593	16	18	50	58	1064	112	90	98	100	104	54
Harvard University	368	368	1.576	2.175	1.534	12	12	46	63	694	117	34	40	40	43	77
University of North Carolina	144	185	778	2.098	792	13	13	35	45	523	73	71	75	75	75	45
State University System of Florida	85	147	609	2.086	629	9	10	28	65	408	84	110	118	119	118	49
Pennsylvania Commonwealth System of Higher Education PCSHE	98	128	562	1.864	605	0	0	20	32	363	70	55	60	60	60	34
University of Texas System	96	98	769	1.693	791	8	9	39	42	472	100	36	38	39	39	63
University College London	152	170	609	1.614	551	10	10	25	54	463	71	41	45	45	48	53
University System of Georgia	57	94	329	1.525	341	11	12	20	45	285	48	72	76	77	76	20
University of Toronto	181	181	826	1.495	812	0	0	30	60	397	90	0	23	23	23	83
Monash university	55	86	420	1.348	440	10	10	26	47	204	67	56	60	60	60	50
University of Melbourne	40	73	562	1.248	505	7	10	20	48	292	66	53	57	60	61	45
California State University System	34	80	271	1.241	322	0	0	22	26	257	40	69	73	73	73	29
University of Sydney	87	102	600	1.159	565	0	5	9	43	178	56	28	29	31	29	42
Johns Hopkins University	319	319	911	1.087	889	25	25	36	40	348	56	34	39	39	40	24
Michigan State University	28	48	157	1.035	158	0	0	0	0	126	0	30	32	32	32	0
University of Oxford	122	136	407	1.020	0	8	8	54	45	196	83	41	49	77	51	72
University of Illinois System	78	98	331	992	350	7	7	21	23	193	35	36	40	40	40	25
University of California Los Angeles	44	51	529	857	534	4	0	46	0	403	61	22	22	24	27	49

analysis of the SDG described in the *Index and Dashboards Report* 2018, while the present study analyzed the documents generated by the Incites tool of the WoS with respect to SDG 04. Nevertheless, this is due to the origin of the information to be analyzed, and it is important to consider that in both studies, SDG 03 and 02 were strongly related with SDG 04. Along this line, the results coincide in that the relationships between the SDG are associated with themes such as Higher Education, Gender, Quality and Education, Mental Health, and Professional Development, coinciding with bibliometric studies that analyzed the specific relationship between Sustainability and Education in diverse regional contexts (Momete & Momete, 2021; Prieto-Jiménez et al., 2021).

The analysis of the keywords reaffirms the relationship between the quality of education and COVID-19 (Agarwal et al., 2022). Other aspects that coincided with studies and official reports that analyzed specific subjects of SDG 04 showed a strong relationship of this sustainable development objective with the subjects of gender (Unterhalter, 2019), education for sustainable development (Ferguson & Roofe, 2020), professional development and economic growth (Cervelló-Royo et al., 2020), poverty, migration, and education (United Nations, 2018b), inequality, rural and urban areas (United Nations, 2017), legal education and sustainable development (Tejani, 2021), schooling and economic development (Hanushek, 2020), social cohesion and social economy of the sustainable market (Camilleri & Camilleri, 2020), mental health, burnout, mental disorders and education (Lund et al., 2018), and lastly, education and changes in pro-environmental behavior (Kanowski et al., 2019). A relevant aspect is that in the five main five keywords from the authors, with respect to their co-occurrence, the presence of terms such as *sustainability* or *sustainable development* was not underlined, which ratifies the continuous methodological and systematic integration errors of the SDG found in some studies (Alonso-Sainz, 2021).

The main sources of publication showed that articles and reviews fundamentally originated from journals in the area of medicine (emphasis on psychology and psychiatry), computational sciences, and in third place, education sciences. This is mainly due to the number of journals indexed in the WoS associated to these sciences, and to the frequent *annual* conferences on Medical Sciences and Technical Sciences. Thus, when analyzing these sources from the perspective of high-impact journals, and the sources with the highest number of documents published on SDG 04,

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most were not indexed in the categories of *Education or Education & Educational Research*. In this sense, an aspect that must be highlighted is the presence of multi-disciplinary journals such as those with the highest index of publication: (1) *Sustainability*, (2) *International Journal of Environmental Research and Public Health*, and (3) PLOS One.

Although co-authorship does not necessarily imply scientific collaboration (Ponomariov & Boardman, 2016), it was observed that countries such as the United States, the United Kingdom, the People's Republic of China, and Australia, had the highest number of published documents, and a high level of collaboration (strength of the relationships). In this sense, when analyzing countries with more than 1000 published documents, five clusters were clearly documented:

- Cluster 1: *Belgium, Denmark, Finland, France, Germany, Israel, Italy, Netherlands, Norway, Poland, Sweden, Switzerland,* and *Turkey*.
- Cluster 2: USA, *Australia, Canada, Japan, Malaysia, New Zealand, China, Singapore, South Korea*, and *Taiwan*.
- Cluster 3: *Brazil,* Chile, Portugal, and Spain.
- Cluster 4: *England*, *Ireland*, and *Scotland*.
- Cluster 5: India and *South Africa*.

When analyzing the top 20 keywords of SDG 04, their clear relationship with the other SDG was clear, with the following relationships underlined:

- SDG 01,02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 12, 13, 14, and 15 (COVID-19 and Education)
- SDG 10, 11, 12, 13, 14, and 15 (COVID-19*, Higher Education,* and *Education*)
- SDG 12, 13, 14, and 15 (COVID-19*, Higher Education, Education,* and *Sustainability*).
- SDG 03, 04, 05, and 10 (COVID-19*, Education,* and *Mental Health*)
- SDG 03, 05, and 04 (COVID-19, *Gender, Depression,* and *Mental Health*)
- SDG 06, 07, and 08 (COVID-19 and *Sustainability*)

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- SDG 01 02, and 05 (*Food insecurity*)
- SDG 06 and 07 (COVID-19, *Motivation, Sustainability,* and *Health*).
- SDG 01 and 02 (COVID-19*, Children,* and *Food Insecurity*)

It is indisputable that the COVID-19 phenomenon had a strong influence on scientific production associated to Education. The analysis of the keywords from the authors showed that this term was strongly associated with the words: *Higher Education, Education, Gender, Mental Health, Teacher Education, Children, Sustainability, Medical Education, Medical Students, Social Determinants of Health, Depression, Burnout,* and *Food Insecurity.* It permeated different disciplines such as: psychology, sociology, economy, education technology, and politics. We are in agreement with Crawford & Cifuentes-Faura (2022) in that there is a scarcity of studies that analyze the impact of COVID-19 on Education and its relation with the other SDG, and with Faura-Martínez et al (2021) on the need to analyze the influence of COVID-19 on Education, from the perspective of the digital divide (Estrada-Molina & Fuentes-Cancell, 2021).

Lastly, with respect to the universities and their scientific production associated to the SDG from the perspective of SDG 04, the following results are underlined:

- The universities: *University of California System* (10 campuses) and *University of London* are underlined due to their scientific production on all of the SDG, while the *University of Michigan* on the first 15 SDG.
- The universities: *Harvard University* and*, Johns Hopkins University* are highlighted for their scientific production on SDG 01, 02, 03 and 05.
- As for the SDG 12, 13 and 14, the following universities are highlighted: *University of California System, University of London, University of Michigan, State University System of Florida,* and *University System of Georgia*.

In all the cases of the universities with the highest number of publications, the presence of the Unites States and the United Kingdom was re-affirmed as the countries with the greatest productivity and influence on SDG 04.

In conclusion, the present study provides the following ramifications and future lines of research in Education: (1) the identification of

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the keywords with the highest occurrence shows a reiterated academic production related with the levels of education, the training of educators, and their professional development in light of the consequences of COVID-19 associated to mental health, motivation, disability, and inclusive education; (2) a growing interest in the scientific community is observed for influencing SDG 04 with their research studies (directly or indirectly). However, the analysis of the keywords shows that the efforts made that achieved curricular sustainability and the explicit integration of the SDG are still insufficient (Torres, 2021), and (3) in the data from *Clarivate Analytics*, it is observed that there is a need to systematize empirical studies that show the education and pedagogic repercussion of COVID-19 on education institutions, educators, and students.

The study conducted has two fundamental purposes: to analyze the scientific production related with SDG 04 during the 2017-2021 period, and verify its level of integration with the remaining SDG. For this, the main sources, authors, institutions, countries, and most-utilized keywords were identified. Given the lack of bibliometric studies related with SDG 04, the present study offers an exploratory overview of the academic production in light of the publications indexed in the *Web of Science Core Collection*, with emphasis on articles and reviews.

A limitation of the present study is that as it only focused on information published in the WoS, other publications from diverse databases such as Scopus and ERIC were ignored. Thus, an opportunity is available to broaden the search strategy through the inclusion of other databases, to afterwards make comparisons and generalizations.

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