

Educação em tempos de pandemia: uma análise bibliométrica da produção científica sobre o tema

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Resumo

O objetivo da pesquisa foi realizar uma análise bibliométrica da produção científica sobre a Educação e a COVID-19 na base de dados Web of Science. A amostra foi composta por 1.664 artigos, publicados em 329 fontes de 2019 a 2021. Além da análise quantitativa no software RStudio, foi aplicada uma análise de conteúdo, considerando os artigos mais citados no período. Os resultados oferecem informações sobre a evolução da pesquisa na área, possibilitando o reconhecimento de possíveis lacunas, apontando Impacts, temas mais recorrentes e estratégias implementadas para manter os processos de ensino e aprendizagem durante o período de pandemia, em especial com relação à educação médica. O trabalho pode ter implicações para pesquisadores da área da educação, docentes em formação inicial e em exercício, bem como formuladores de políticas públicas.

Palavras-chave: Análise de Conteúdo. Bibliometria. COVID-19. Web of Science.

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Education in pandemic times: a bibliometric analysis of the scientific production on the topic

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Abstract

The objective of the research was to carry out a bibliometric analysis of the scientific production on Education and COVID-19 in the Web of Science database. The sample consisted of 1,664 articles, published in 329 sources from 2019 to 2021. In addition to the quantitative analysis in the RStudio software, a content analysis was applied, considering the most cited articles in the period. The results provide information on the evolution of research in the area, enabling the recognition of possible gaps, pointing out impacts, the most recurrent themes and strategies implemented to maintain the teaching and learning processes during the pandemic period, especially in relation to medical education. The work may have implications for researchers in the area of education, teachers in initial training and in practice, as well as public policy makers.

Keywords: Content Analysis. Bibliometry. COVID-19. Web of Science.

La educación en tiempos de pandemia: un análisis bibliométrico de la producción científica sobre el tema

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Resumen

El objetivo de la investigación fue realizar un análisis bibliométrico de la producción científica sobre Educación y COVID-19 en la base de datos Web of Science. La muestra fue compuesta por 1.664 artículos, publicados en 329 fuentes entre 2019 y 2021. Además del análisis cuantitativo en el software RStudio, se aplicó un análisis de contenido considerando los artículos más citados en el período. Los resultados ofrecen información sobre la evolución de la investigación en el área, permitiendo el reconocimiento de posibles lagunas, señalando los Impacts, los temas más recurrentes y las estrategias implementadas para mantener los procesos de enseñanza y aprendizaje durante el período de pandemia, en particular en lo que respecta a la educación médica. El trabajo tiene implicaciones para los investigadores educativos, los profesores en formación inicial y en servicio, así como para los responsables de las políticas públicas.

Palabras clave: Análisis de Contenido. Bibliometría. COVID-19. Web of Science.

Introduction

Various studies point out the new challenges faced in promoting teaching during the COVID-19 pandemic, as well as the efforts made by educators and researchers to make this process more engaging and learning more meaningful (GOMES *et al.*, 2020; GARCIA-PENALVO *et al.*, 2020; CHICK *et al.*, 2020).

Current research efforts are appropriate and should be encouraged because, with the occurrence of the pandemic, proposing and disseminating remote teaching strategies are necessary actions to address the natural effects of social distancing (GOMES *et al.*, 2020). However, it is known that the exponential increase in the number of studies and publications does not always represent an immediate application of the findings, especially in the field of education, where the gap between research and classroom practice is even more evident (LAWLOR *et al.*, 2019).

Another point to highlight is that an increase in research output, in quantitative terms, does not always represent a gain in terms of innovation, impact, and applicability. For this reason, after two years in this context, before making new proposals for education in pandemic times, it is important to pause and analyze the path taken. An analysis of publications in the field of education, focusing on teaching and learning processes during the COVID-19 pandemic, may allow for the sharing of some functional practices already tested with students, as well as assess the evolution of the topic and a careful consideration of possible gaps that could open space for innovations in the field.

Such research can also be relevant in the current context, given that the need to quickly publish data related to the topic, coupled with the shorter peer-review timeline, may contribute to a decrease in the quality of publications (PIRES *et al.*, 2021). In this sense, a quantitative analysis combined with a qualitative analysis of the data can provide a more comprehensive view of the scenario and an accurate description of the most impactful works.

Given the above, this research aimed to conduct a bibliometric analysis of the scientific production related to education, particularly teaching and learning processes, focusing on the COVID-19 pandemic. Bibliometric analyses enable the dissemination of proposals with greater impact in specific research areas and have proven to be a consistent alternative in current educational research (HUANG *et al.*, 2019; HERNÁNDEZ-TORRANO; SOMERTON; HELMER, 2020).

This is because, in addition to allowing the collection and processing of large amounts of information, bibliometric studies also enable the evaluation of national and international academic production, identifying the most relevant and current topics, and assisting in scientific dissemination,

identifying gaps, and proposing innovations across all fields of study (HASSAN; HADDAWY, 2015). Thus, considering the outlined arguments, as well as the current and emerging context that the pandemic has brought, as Costa et al. (2020) assert, the contribution of studies aiming to disseminate bibliometric indicators related to COVID-19 publications is evident.

Other researchers have conducted similar proposals (COSTA et al., 2020; SILVA *et al.*, 2020; GICOVATE *et al.*, 2020; PIRES *et al.*, 2021) by analyzing scientific production on COVID-19 in different databases such as Scopus and Web of Science (WoS). Although these are bibliometric analyses, none of these studies aimed to analyze the relationship between the pandemic and education. The only article found directly associated with the theme, and that used bibliometrics as a method, was by Barros and Vieira (2021). The authors aimed to identify the main challenges educators have faced during the pandemic to ensure civic education, as well as to present alternatives being adopted to overcome these challenges. Although it overlaps with the objective of our proposal, the methods used in their research were quite different, starting with the database used to search for articles (Google Scholar), as well as the descriptors used in the search ("challenge," "teaching," and "pandemic"), which resulted in works very different from those analyzed in our sample.

Thus, the purpose of the present article was, in addition to extending the research of the aforementioned authors in terms of time, content, and internationalization, to also provide a general description of the current state of the field, considering: 1) the main journals involved in the research, 2) the countries that contribute the most to the development of proposals in the area, 3) citation networks, and 4) the most addressed themes in the articles in general and in the most cited articles in the area. To better understand the last item, the researchers conducted a content analysis (BARDIN, 2011), categorizing the most cited articles during the analyzed period.

Methodological Procedures

Characterization of the Research

This is a basic, descriptive-exploratory research with a mixed approach, and in terms of procedures, it is a literature review (PRODANOV; FREITAS, 2013). The technique used for data collection and analysis was bibliometrics, utilizing metadata extracted from the WoS database. Additionally, a qualitative analysis of the sample of articles was performed through content analysis (BARDIN, 2011). Bibliometrics has been used as a synthetic and robust method for investigating a specific field, contributing substantially to policy formulation, trend analysis, and future perspectives in the evaluated research field (AGARWAL *et al.*, 2016). The following describes the methods for

Education in pandemic times: a bibliometric analysis of the scientific production on the topic quantitative and qualitative data collection and analysis.

Data Collection and Sample Delimitation

The review described in the article followed these steps: selecting research objectives, establishing inclusion and exclusion criteria for manuscripts, defining the information to be extracted based on the objectives, and analyzing and discussing the results (PEREIRA, 2011).

Thus, after defining the research objectives outlined in the introduction, a search was conducted in the WoS database to select the articles. The database was chosen due to its broad coverage and internationally accepted measures for evaluating journals, and it is also the primary source of data used to obtain bibliometric indicators (RAFOLS *et al.*, 2016; TESTA, 2015).

Descriptors for the search were selected from the UNESCO Thesaurus of Education and the Descriptors in Health Sciences (DECS – BIREME), namely: “COVID-19”, “Coronavirus”, “Education”, “Teaching”, and “Learning”. After selecting the descriptors, boolean operators “and” and “or” were applied to the search formula to make it as complete and comprehensive as possible. It is important to note that the search was conducted in English and used the “advanced search” tool. Given this, the search formula with each term used is: TS = ("COVID-19" OR "Coronavirus") AND (education OR teaching OR learning).

The criteria for including works were: 1) only publications included in categories related to education, namely: “Education Educational Research”, “Education Scientific Disciplines”, “Education Special”, and “Psychology Educational”; 2) only publications available from 2019 to April 22, 2021; and 3) publications that had the descriptors in the title, abstract, or keywords of the article. Works published in conferences, as well as letters and book chapters, were excluded from the sample.

Data Analysis

For the data analysis, all files found were exported from the WoS database into the RStudio software, where the Bibliometrix package (ARIA; CURCCURULLO, 2017) was used to identify the desired characteristics, namely: 1) the main journals involved in the research, 2) the countries contributing most to the development of research in the field, 3) citation networks, and 4) the themes most frequently addressed in the articles in general and in the most cited articles in the area. For the latter, in addition to using Bibliometrix, a content analysis (BARDIN, 2011) was also conducted to categorize the themes addressed in the most cited articles.

It is worth noting that to obtain the citation networks, the Biblioshiny tool, accessed through RStudio, was used. Biblioshiny provides a web interface for managing data from the Bibliometrix

package. To construct and visualize bibliometric networks, the software employs three stages: normalization, mapping, and clustering (ARIA; CURCCURULLO, 2017). The units of analysis (publication data) are represented in the maps as rectangular nodes. Related nodes are connected by lines, with the thickness of the lines representing the strength of the relationship between the two nodes. Additionally, the relative position and color of the nodes on the map represent the interrelation of these nodes.

Regarding the citation networks, these were generated using the Louvain clustering algorithm available in Biblioshiny. The analysis considered the 50 most cited papers that were cited at least twice by other papers also present in the clusters, with isolated authors removed. For graphical representation, the largest amount of data possible was considered to ensure readability, as too many grouped articles could make the graph difficult to interpret.

For the content analysis of the articles, the word count tool in the software was initially used to identify the most frequent words in the titles, abstracts, and keywords of the articles to gain an overview of the sample. Subsequently, to gain a deeper understanding of the most impactful themes, content analysis (BARDIN, 2011) was applied to the most cited articles during the period.

Initially, a preliminary analysis of the data was conducted by selecting articles cited at least 10 times during the analyzed period (2019 to April 2021). Following this, a detailed reading and coding of the articles were performed, tabulating the title, authors, year of publication, and, in summary, the objectives, methodology, and main conclusions. After this process, the articles were numerically coded, and coding units were selected to aggregate the publications based on common characteristics, leading to the establishment of thematic categories a posteriori according to semantic criteria, which are presented in the results (BARDIN, 2011).

Results and Discussion

General Characteristics of the Publications

The 1,664 articles found were published in 329 sources over the nearly three years considered in the research. Of these, 1 article was published in 2019, 999 in 2020, and the remaining 664 in the first four months of 2021. The trend in publications in the field reveals an exponential increase, which is expected given that we are still experiencing a period of pandemic with all its social, educational, and economic ramifications.

Regarding the journals with the highest number of publications, about 30% (485) of the total manuscripts were published in ten journals listed in Table 1. Notably, the first journal, Journal of

Education in pandemic times: a bibliometric analysis of the scientific production on the topic Chemical Education, published a total of 171 articles during the period, accounting for about 10% of the publications. This indicates that the journal may be considered the most influential in the field to date and a significant source of research on the topic. These numbers are explained by the launch of special calls for pandemic-related issues and the insights obtained by researchers on teaching during the period.

Table 1 - The 10 Journals with the Most Publications in the Field During the Established Period

Journals with the Highest Number of Publications		Number of Articles
1.	Journal of Chemical Education	171
2.	German Medical Science Journal for Medical Education	51
3.	Education Sciences	50
4.	Pharmacy Education	44
5.	Biochemistry and Molecular Biology Education	35
6.	Revista Romaneasca Pentru Educatie Multidimensionala	34
7.	BMC Medical Education	29
8.	Educational Technology Research and Development	24
9.	International Journal of Technologies in Higher Education	24
10.	Journal of Surgical Education	23

Source: Elaborated by the authors.

Another relevant finding is that, when analyzing the most cited sources, the Journal of Chemical Education still ranks first, with 1,483 citations of its articles by the sample articles. This is followed by Computers & Education, which has 564 citations. Although Computers & Education does not rank among the top journals by the number of articles published during the period, it has a broad range of articles focused on educational technologies. This suggests that the topic of educational technology is frequently addressed in the articles published during this period. Notably, 35% of the cited journals are related to technology, and 25% are related to medical education.

Figure 1 shows the distribution of publications by country, indicating how many publications had corresponding authors from each country. The United States leads with 27% of the publications, followed by the United Kingdom with 6.3%, and Spain with 4.6%. However, a significant increase in the number of published articles does not always correspond to a proportional rise in the internationalization of science within a country (RAMOS, 2018). It is worth noting that only 6% of

the publications from corresponding authors in the United States involve researchers from multiple countries.

Figure 1 - Countries that published the most articles on the topic researched in the period from 2019 to April 2021. The top 10 countries were: USA (456), UK (105), Spain (77), Australia (76), China (72), Canada (60), Germany (60), Brazil (58), India (38) and Russia (30).



Source: Elaborated by the authors.

In this case, the United Kingdom and Australia lead in publications with the highest level of internationalization, publishing 22% and 21% of their articles with authors from multiple countries, respectively. Besides the United States, mentioned earlier, the countries with the least international cooperation relative to the number of research studies in the field are Russia (0%), Brazil (5%), Canada (7%), India (10%), Spain and Germany (both 13%), and China (15%). Regarding international cooperation during the pandemic period, Ventura et al. (2020) state that such collaboration is crucial for mastering globally employed methodologies and enhancing the ability of researchers from developing countries to question and contribute to emerging critical schools of thought.

Another noteworthy point is the funding agencies for research in the field. Despite a considerable volume of published research, studies in education have historically received low investment. The agencies that funded at least 5 studies are: The National Science Foundation of the United States (17), the Department of Health of the United States (11), the National Institutes of Health (9), the European Commission (5), and the National Council for Scientific and Technological Development (CNPq) (5). All other institutions funded fewer than 5 studies during the period.

All the aforementioned agencies are institutions from countries that are among the top ten in terms of publication volume. As expected, countries receiving higher investment naturally have more active

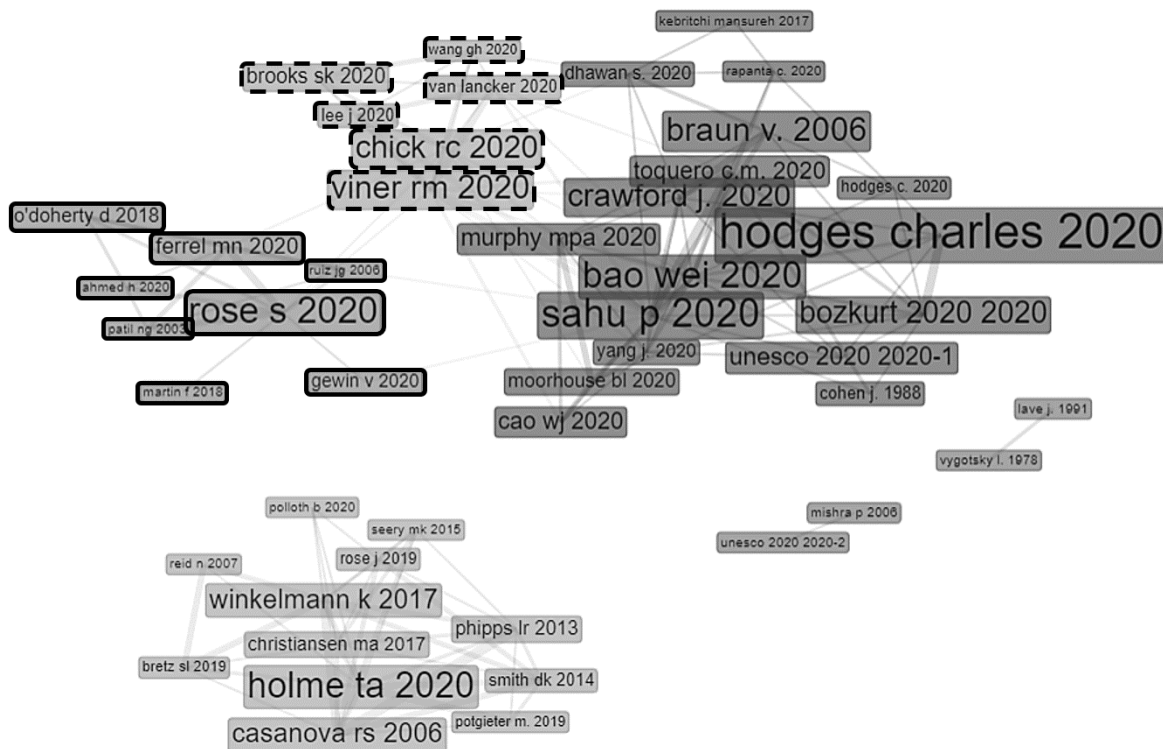
Education in pandemic times: a bibliometric analysis of the scientific production on the topic researchers and more publications. The lack of financial support remains one of the challenges for the development of research proposals in the educational field.

Analysis of Co-citation Networks

Co-citation networks reveal important aspects of research in the field. This is because bibliographic coupling can identify research lines or thematic areas that group related works, as well as the positioning of researchers publishing in the area. Figure 2 shows the results of the search considering the 50 most cited works. It is worth noting that only those among the 50 with at least 2 connections between them were considered. In the figure, four robust and well-defined clusters can be identified, with the most cited works appearing in larger and generally more central boxes. Below, we will provide a summary of these works, revealing the possible guiding theme of these clusters.

The titles and abstracts of research in the dark gray cluster appear to focus on the differences between well-planned online learning experiences and online courses offered during crises. Additionally, some works present an analysis of the challenges and most effective strategies for promoting quality online education, as well as an analysis of the potential impact of the severe COVID-19 outbreak on the mental health of students and technical-pedagogical support staff.

Figure 2 - Co-citation network revealing well-established clusters regarding citations. The larger the box, the more cited the work.



Source: Elaborated by the authors.

The article by Hodges *et al.* (2020), for example, argues that there is a stigma surrounding online learning, suggesting that the method is of lower quality compared to in-person learning, despite research showing otherwise. However, the authors also emphasize that the sudden shift of many institutions to online education under the circumstances it occurred hastily hindered the process and prevented those involved from fully leveraging the resources and possibilities of the format.

Effective online education requires investment and a student support system, which takes time to plan and develop. Therefore, the authors conclude that through careful analysis, teachers, staff, and students can together evaluate their efforts, identify strengths and weaknesses in the process, and better prepare for future needs by implementing what they refer to as “Emergency Remote Teaching.” (HODGES *et al.*, 2020).

In Bao’s article (2020), as a result of the online teaching observations at Beijing University, six instructional strategies are presented to improve students' concentration and engagement in learning, in order to achieve a smooth transition to online learning. Strategies are: 1) be prepared for unexpected problems with the online education platform with a contingency plan before classes start and inform

Education in pandemic times: a bibliometric analysis of the scientific production on the topic students in advance; 2) divide the teaching content into smaller units to help students concentrate; 3) focus on speech, speaking slower in some moments to allow students to capture key points of knowledge; 4) work with and obtain online support from teaching assistants or monitors; 5) reinforce, through appropriate activities, the need for developing active learning ability of students outside the classroom; and 6) effectively combine online learning and autonomous learning, or self-learning, offline.

Finally, Sahu (2020) addresses the challenges of the new remote teaching modality, ranging from issues such as the presence of exchange students and difficulties in distance evaluation processes, to concerns related to the potential impact of the pandemic on the mental health of students and technical-pedagogical support staff.

The light-gray cluster is the second largest and features research in the field of chemistry education. This pattern appears consistent with the finding that the Journal of Chemical Education is the leading journal in terms of the number of publications in the sample. The most cited article in this cluster is Holme (2020), an editorial that discusses articles with approaches tested during the pandemic, revealing how and how well they worked. Other highly cited articles in this cluster include Casanova *et al.* (2006) and Winkelmann *et al.* (2017), which present distance education and virtual resources as a viable alternative to the conventional laboratory format in chemistry.

The black-bordered cluster focuses more on health education, particularly medical education. The most cited work in this cluster is Rose (2020), which discusses the current state of medical education, describes how COVID-19 may impact learning environments, and explores the potential implications of the pandemic for the future of medical education. The author concludes that advancements in telehealth, adaptive research protocols, and flexible clinical trial approaches may be some positive outcomes of this period. Additionally, students and educators can help document and analyze the effects of current changes to learn and apply new principles and practices for the future.

Lastly, the smallest cluster, with a dotted border, contains works focusing on the analysis of institution closures during the pandemic and their effects. The work by Chick *et al.* (2020) is focused on concerns about maintaining medical education. In this article, the authors present strategies used to sustain surgical resident education during the pandemic, including the flipped classroom model, teleconferencing instead of in-person lectures, involving residents in telemedicine clinics, procedural simulations, and using surgery videos. The authors state that, although there is no substitute for practical learning through surgical experience, these methods may help fill the educational gap for residents and mitigate the loss of exposure to learning during this time.

Viner *et al.* (2020a) highlight the significant drawbacks of prolonged school closures. The authors conducted a systematic review, searching three electronic databases to identify what is known about the effectiveness of school closures and other school-based social distancing measures during coronavirus outbreaks. Their findings indicate that data from outbreaks in mainland China, Hong Kong, and Singapore suggest that school closures did not contribute to controlling the epidemic.

In another similar study, Viner *et al.* (2020b) argue that evidence supporting the global closure of schools for controlling COVID-19 is scarce, in contrast to the damage associated with prolonged school closures. These damages include impacts on learning, reduced physical activity, and a range of mental health and well-being issues due to social isolation, reduced social support, increased exposure to domestic violence, exclusion of children from school with public health interventions, and the exclusion of vulnerable students from social safety nets that operate in schools. Additionally, these harms are more pronounced in lower-income families, exacerbating health and educational disparities.

The third most cited work in the cluster, Brooks *et al.* (2020), also suggests that decisions regarding quarantine measures should be based on the best available evidence. The authors conducted a review of the psychological impact of quarantine using three electronic databases. Most of the studies reviewed reported negative psychological effects, including symptoms of post-traumatic stress disorder, confusion, and anger.

Analysis of Word Frequency and Content Analysis of High-Impact Articles

Although the subjects mentioned above are predominant in the most cited articles from the clusters, a comprehensive evaluation was conducted through a word frequency analysis of the titles, abstracts, and keywords of each article included in the sample of this research. Isolated terms already used in the search, such as "teaching," "learning," "education," "COVID-19," and "pandemic," were removed.

The results of this analysis are presented in Table 2 and allow us to infer that the primary target audience for most of the productions was higher education students, particularly medical students. It is also evident that there is a focus on the early years of undergraduate studies rather than on other stages. This analysis reveals a gap concerning research directed towards elementary, middle, and adult education, for example. Naturally, terms such as "remote teaching" or "online," "distance education," and "online learning" are central to the productions, as these alternatives were the most employed in teaching during times of social distancing. However, the frequent appearance of terms like "impact" and "challenges" reflects the sentiment and undeniable effects that the implementation

Education in pandemic times: a bibliometric analysis of the scientific production on the topic of emergency remote teaching has had on those involved in the process (BROOKS *et al.*, 2020; HODGES *et al.*, 2020; VINER *et al.*, 2020).

Table 2 - Most Frequent Words in Titles, Abstracts, and Keywords of the 1664 Articles in the Sample.

Title	Freq uency	Abstract	Frequ ency	Keywords	Frequ ency
Online	326	Online	3029	Online Learning	123
Remote	129	Teachers	1390	Higher Education	108
Distance	115	University	869	Distance Learning	107
Medical	113	Medical	842	First Year of Undergraduate Study	67
University	103	Desafios	828	e-learning	66
Teachers	101	Distance	787	e-learning	65
Chemistry	99	Curso	781	Curriculum	60
Higher Education	99	Social	774	Self-Instruction	55
Impact	89	Remote	754	Medical Education	55
Escola	87	Virtual	711	Second Year of Undergraduate Study	50

Source: Elaborated by the authors.

Terms that also stand out are “curriculum” and “self-instruction.” Reconsidering curricula was an essential task during the period. However, some educators faced difficulties adapting content using new technologies, considering that not everyone has the appropriate spaces and equipment, in addition to the fact that there was no specific curriculum for remote teaching (LIMA; AZEVEDO; NASCIMENTO, 2020; SILVA, 2020).

However, the difficulty in summarizing and selecting aspects of the content also lies in the fact that there is still an overemphasis on curricular content in schools, as well as pressure from parents and sometimes from students themselves to cover the content of the textbook. Otherwise, this could represent an irreparable loss in learning (OLIVEIRA; MOUSINHO, 2020).

However, in a situation like the one the school community is currently facing—dealing with the loss of family members, establishing a new teaching modality as an emergency measure, without time for preparation, and handling an extensive content load—it becomes urgent and necessary, as Silva (2020) states, to adopt a curriculum that is not limited to what was outlined in legal or legislative

frameworks under ideal conditions. A dynamic curriculum is needed, one that adapts to the current situation and continues to strive for better learning outcomes, without disregarding the context in which both students and educators are situated.

The literature emphasizes that methodologies used in a curriculum designed for in-person teaching can be adapted to the new reality. However, it is essential to focus on presenting content in a modular way and even summarizing it, selecting only truly essential aspects to make learning less exhausting during a crisis period like the one currently experienced (BAO, 2020).

Regarding "self-instruction," this is not a recent field of study. Other researchers have already highlighted its functionality in hybrid methods, active learning, and the structuring and dissemination of MOOCs (Massive Open Online Courses) (FASSBINDER; FASSBINDER; BARBOSA, 2016; LEOPOLDO, 2015). The goal is to provide active learning opportunities where students study independently, using modules and individual worksheets directed at them, consulting the teacher in case of doubts or difficulties in understanding. This description largely clarifies the recent need for this method, as the strategy allows for student autonomy while enabling teachers to address individual needs more specifically (BAO, 2020).

Regarding the most impactful articles in the field (most cited), they are listed in Table 3. Content analysis was applied with categories structured *a posteriori*, as outlined by Bardin (2011). The categories are listed in Table 3, and the content composing them will be described separately in the following subsections.

Education in pandemic times: a bibliometric analysis of the scientific production on the topic
Table 3 - Publications in Each Category. The categories containing the most influential papers, based on the average number of citations, are Categories 3 and 5.

Title / Average Citations	Author / Year	Frequency
CATEGORY 1 Challenges and adaptations of teachers, students, and administrators of educational institutions during the pandemic / 21.4	ALMAIAH; AL-KHASAWNEH; ALTHUNIBAT, 2020.	27
	WATERMEYER <i>et al.</i> , 2021.	26
	KOENIG; JAEGER-BIELA; GLUTSCH, 2020.	24
	GARCIA-PENALVO <i>et al.</i> , 2020.	21
	JOHNSON; VELETSIANOS; SEAMAN, 2020.	19
	LYONS; CHRISTOPOULOS; BROCK, 2020.	17
	HUBER; HELM, 2020.	16
CATEGORY 2 Concerns, preferences, attitudes, and opinions of medical students regarding the COVID-19 pandemic and its consequences / 18.4	SOLED <i>et al.</i> , 2020.	33
	CHOI <i>et al.</i> , 2020.	24
	HE <i>et al.</i> , 2020.	19
	CERVERA-GASCH; GONZALEZ-CHORDA; MENA-TUDELA, 2020.	14
	CHANDRATRE, 2020.	14
	COMPTON <i>et al.</i> , 2020.	14
	JERVIS; BROWN, 2020.	11
CATEGORY 3 Impacts of the pandemic on medical education and strategies to sustain teaching in the field during this period / 51.3	CHICK <i>et al.</i> , 2020.	115
	LIANG; OOI; WANG, 2020.	25
	CLELAND <i>et al.</i> , 2020.	14
CATEGORY 4 Teacher training during the pandemic / 17.3	MOORHOUSE, 2020.	29
	SCULL <i>et al.</i> , 2020.	12
	ASSUNCAO-FLORES; GAGO, 2020.	11
CATEGORY 5 Adaptations in anatomy teaching in response to the pandemic / 39.5	PATHER, <i>et al.</i> , 2020.	47
	LONGHURST <i>et al.</i> , 2020.	32
CATEGORY 6 Effects of the pandemic on individuals with special educational needs and their caregivers / 14.5	YARIMKAYA; ESENTURK, 2020.	17
	NEECE; MCINTYRE; FENNING, 2020.	12

Source: Elaborated by the authors.

Category 1: Challenges and adaptations of educators, students, and administrators of educational institutions during the pandemic”

In this category, Almaiah, Al-Khasawneh, and Althunibat (2020) explore the challenges of using e-learning and investigate the key factors supporting the system's use during the pandemic. Based on the results, the critical factors affecting e-learning use are: (1) technological issues, (2) system quality, (3) cultural aspects, (4) self-efficacy, and (5) trust. Additionally, the results indicate three main challenges impeding system use: (1) change management issues, (2) technical problems with the system, and (3) financial support for usage.

The article by Watermeyer *et al.* (2021) discusses the concerns of educators arising from their rapid transition to online teaching. Overall, educators report that the shift to online learning is causing significant dysfunction and disruption in their pedagogical roles and personal lives, as well as difficulties in maintaining student engagement. Although some technology advocates see the current moment as an opportunity to push for a digital transition, the aggressive manner in which it is being implemented, in an emergency context, has overburdened workers and reduced the view of remote teaching to simply “posting materials online” in many cases. In this vein, the article by Koenig, Jaeger-Biela, and Glutsch (2020) points out that while the use of technology is important and valid, schools should aim for a hybrid learning approach. After all, schools are also places for collaborative peer learning and play a significant role in students' social development.

Koenig, Jaeger-Biela, and Glutsch (2020) examined whether early-career teachers are adept at handling the key challenges of remote teaching. This target group was chosen because it was expected that teachers from the digital native generation would have an easier transition from face-to-face to remote teaching. However, the results reveal that this does not guarantee that teachers have developed sophisticated digital skills, and it is crucial to prioritize the development of "Technological Pedagogical Knowledge" in both initial and ongoing teacher training.

In response to the concerns expressed, the work of Garcia-Penalvo *et al.* (2020) provides a guide with recommendations for adaptation, preparation and correction of evaluations in remote mode. The guide includes the following main recommendations: 1) the number of tests should be consistent with the skills required in the subject, it is highly advisable to diversify the evaluation methods, 2) continuous assessment should be used, in order to reduce the effect of a single final test, 3) when necessary general and final assessment tests with weight equal or greater than 40% of the average, the maximum level of identification of students must be guaranteed, tests and exams should be based

Education in pandemic times: a bibliometric analysis of the scientific production on the topic on a large database of questions or items that are randomly selected and programmed for a short maximum response time, 5) practical tests may require only a basic level of identification,) it is advisable to use evaluation rubrics, especially to enable peer review systems; 7) oral presentations can be used using videoconference tools of limited duration, 8) plagiarism control tools must be used for activities to be delivered.

Lyons, Christopoulos and Brock (2020) present quick solutions implemented in pharmacy education. Among the suggested solutions are: to encourage students to present learning results of the weekly topic; offer online learning activities before class; provide live interactive lectures, even if asynchronous classes are recommended most of the time; provide frequent feedback to students and ask for feedback from them on proposals; make online discussion forums available in real time and rooms for small group activities; and to encourage students to self-assess their involvement.

The focus of the work by Johnson, Veletsianos, and Seaman (2020) was on the effects of the rapid transition to remote teaching for teachers and administrators of educational institutions. The administrators reported that both experienced and inexperienced online teachers were committed to continuing their activities and using new teaching methods. The main areas where teachers and administrators identified a need for assistance included student support, greater access to online digital materials, and guidance for working from home.

The article by Huber and Helm (2020) presents the limitations and potential implications of rapid surveys known as "School Barometer Surveys," concerning the reliability and validity of the data to provide initial insights into the situation during the pandemic. The main topics covered by the School Barometer Survey included: the flow of school authorities; reactions to school closures; perceived stress due to the COVID-19 crisis; digital teaching and learning; and the demands and expectations of parents, students, and school staff.

With regard to teaching and learning processes, the results to be highlighted from the analysis of Huber and Helm (2020) are: 1) a substantial proportion of students reported a disturbingly low level of learning at home during school closure; 2) the Teachers' skills related to the use of digital instructional formats were classified as mediocre; 3) feedback on learning tasks and individual learning support were considered a central feature of instructional quality; and 4) among the groups of actors surveyed, students and school managers reported the highest degree of perceived stress compared to Teachers and other employees.

Category 2: "Concerns, Preferences, Attitudes, and Opinions of Medical Students Regarding the COVID-19 Pandemic and Its Implications"

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From the perspective of medical students, Jervis and Brown (2020) highlight difficulties associated with preparing for exams under such unique and challenging circumstances as the pandemic. The authors emphasize that working from home, during social distancing, involves students in additional family tensions experienced by everyone during this pandemic. When discussing the exams taken by students in their final year, the authors state that this situation, combined with a new and unfamiliar exam format, inevitably leads students to feel frightened and may encourage cheating, a fact corroborated by the literature (KUSNOOR; FALIK 2013).

Choi *et al.* (2020) also present the impact of COVID-19 on final-year medical students. The authors state that the primary concern for most students is that they feel less prepared to start working as medical professionals, and that interruptions to their placements have had a significant impact on their sense of readiness. In agreement, Chandratre (2020) finds that medical students are experiencing increased anxiety during the pandemic, high rates of depression, and are less likely to seek support, highlighting the importance of safeguarding their mental health and implementing effective strategies to support their well-being.

Additionally, He *et al.* (2020) examines the concerns of residents as they prepare to be on the front lines of the response to the coronavirus. Common personal concerns reported include the risk of transmitting the virus to family members and patients, excessive workload, and the risk of acquiring the infection. Despite these concerns and feeling inadequately prepared, the students in both studies express readiness and agree that assisting in hospitals during the outbreak would be a valuable learning opportunity (Choi *et al.*, 2020; He *et al.*, 2020). In this context, Compton *et al.* (2020) assessed students' preferences for returning to clinical settings during the COVID-19 pandemic. The results show that approximately 65% of students prefer to return to the clinical environment.

The aforementioned studies highlight the opinions and willingness of medical students to care for COVID-19 patients. Cervera-Gasch, Gonzalez-Chorda, and Mena-Tudela (2020) note that while this analysis is common in research, no prior studies had explored students' opinions on the policies adopted to contain outbreaks. The researchers analyzed students' opinions on topics such as the initial COVID-19 containment policies adopted in Spain, the recommendations from the Spanish Ministry of Health for preventing and treating COVID-19, and their attitudes, confidence, and willingness to handle cases of infected individuals.

The results align with the previous findings (Choi *et al.*, 2020; He *et al.*, 2020; Compton *et al.*, 2020), indicating that students are willing to care for COVID-19 patients. However, they express concern over the lack of specific training and suggest that more resources should be allocated to

Education in pandemic times: a bibliometric analysis of the scientific production on the topic Health Education. Additionally, many disagree with the political measures adopted to contain the spread of COVID-19, which included holding sports events behind closed doors, suspending flights to certain countries, and canceling sociocultural events.

Finally, Soled *et al.* (2020) report on the actions of student leaders from Harvard Medical School, who established a Student Medical Response Team for COVID-19. The team worked by identifying needs in various areas and quickly engaging students in targeted efforts to find solutions. Four virtual committees were structured, focusing on: 1) evidence-based information for the medical community; 2) information tailored for the broader public; 3) activism for clinical support; and 4) community advocacy. The team helped mobilize hundreds of students rapidly and serves as a useful model for other institutions and hospitals during COVID-19.

Category 3: "Impacts, Strategies, and Opportunities Generated by the Pandemic Regarding Medical Education"

In general, within this category, researchers assert that although lectures still constitute the cornerstone of medical education, exploring creative solutions for the continuity of medical training during times of crisis using e-learning platforms, simulation, and remote tutorials should be prioritized. (CHICK *et al.*, 2020; LIANG; OOI; WANG, 2020; CLELAND *et al.*, 2020).

The article by Chick *et al.* (2020) is the most cited across all categories, and the strategies it suggests were described earlier in the characterization of the clusters. The article by Cleland *et al.* (2020) details the results of a chat analysis during a webinar hosted by the International Association for Medical Education, which involved medical professionals from five continents. The analysis of comments indicated challenges educators were facing in adapting medical training programs to a remote modality. The main areas impacted by the pandemic mentioned by educators included: teaching and learning; clinical education; assessment; and the needs of educators.

Regarding medical education, Liang, Ooi, and Wang (2020) point out that, in addition to specific knowledge, teamwork, empathy, courage, and compassion are important qualities that should be instilled in all medical students and trainees. Furthermore, maintaining medical training during a crisis such as the one we are experiencing can be an opportunity to help students develop these characteristics.

Category 4: "Teacher Training in Times of Pandemic"

While Assunção-Flores and Gago (2020) describe the challenges of teacher training, analyzed from the perspective of initial teacher education in Portugal, Moorhouse (2020) examines the same target group in Hong Kong, and Scull *et al.* (2020) conducts research in Australia.

Among the challenges mentioned in the articles is the conduct of practice-based modules, such as internships. Assunção-Flores and Gago (2020) point out that students had to conduct observations and propose interventions for their internships remotely, which complicated the process of observation, monitoring, and mentoring of these trainee teachers.

As positive aspects of the process, the authors note that the new teaching context required continuous adaptation, offering significant learning opportunities for those involved (ASSUNÇÃO-FLORES; GAGO, 2020). The main criticisms include the lack of specific national recommendations, only general recommendations emphasizing the importance of maintaining interaction with students and conducting online teaching, making necessary adjustments in pedagogy and assessment. Additionally, they warn that the immediate responses from teachers, within a compliance logic with new rules, might reinforce a more instrumental and narrow view of teaching. In agreement with this, La Velle and Flores (2018) assert that such a stance contributes to understanding teachers as mere executors or implementers of actions rather than as activists and committed professionals whose practice and pedagogical actions are research-based.

In response to the question “what can be done to keep pre-service teachers engaged even in remote teaching?” Scull et al. (2020), which interviewed four pre-service teachers with high levels of interaction, presents three important points: 1) educators should strive to build quality relationships with pre-service teachers in online environments to reduce feelings of isolation and increase engagement; 2) it is necessary to provide timely constructive feedback; and 3) expectations of progress need to be adjusted, as students in online formats may not learn at the same pace as those in face-to-face education.

The last study describes adaptations made in a teacher education course at Monash University, Australia. Previous literature revealed that education students at this university reported high levels of satisfaction with the online experience during the pandemic (SCULL, 2020). Moorhouse (2020) then describes the adaptations made, which align with the findings of Scull *et al.* (2020) and Assunção-Flores and Gago (2020). The author describes a common combination of asynchronous and synchronous modes of instruction, as previously noted in other articles.

However, Moorhouse (2020) points out that the tutor mentioned fewer than ten students attended synchronous classes, unlike in-person sessions. Thus, after three sessions, the article describes that the tutor adapted the approach by making synchronous sessions mandatory and using small group discussions, providing more rooms within the session structure. Consequently, the tutor allocated students into discussion groups and monitored the discussions by entering different rooms throughout

Education in pandemic times: a bibliometric analysis of the scientific production on the topic the class. These adaptations led to higher attendance and greater student participation.

Category 5: "Adaptations in Anatomy Teaching in Response to the Pandemic"

The two articles included in this category aimed to identify the changes and strategies adopted in anatomical education during the COVID-19 pandemic, as well as the opportunities and challenges of remote learning (PATHER *et al.*, 2020; LONGHURST *et al.*, 2020). The results of the articles are similar, indicating that time management, lack of resources, and technical capacity were clear challenges for educators. Among the strategies applied in anatomy teaching cited in the articles are: use of pre-recorded videos, discussion forums, and activities involving active methodologies for asynchronous sessions, as well as practical activities with synchronous approaches, using software with 3D cadavers, video-atlases, animations, or virtual dissection resources for anatomical structure visualization (LONGHURST *et al.*, 2020; PATHER *et al.*, 2020).

Assessments were mentioned as challenging by both studies. Online questionnaires were widely used, and educators tried to mitigate the risk of cheating by providing questions with random sequences for students or incorporating teamwork as part of the assessment strategy.

It is worth noting that, as guidance for managing the transition from in-person to remote anatomical education, Pather *et al.* (2020) present six essential elements identified from educators' responses to virtual questionnaires: 1) adopting change and maintaining flexibility regarding teaching methods; 2) maintaining clear and consistent communication with students; 3) clarifying expectations and new learning objectives; 4) aligning new material constructively, considering the new context; 5) focusing on community care; and 6) planning for adaptation and continuity of functional strategies in the face of this global health emergency.

Category 6: "Effects of the Pandemic on Individuals with Special Educational Needs and Their Caregivers"

The articles in this category (YARIMKAYA; ESENTURK, 2020; NEECE; MCINTYRE; FENNING, 2020) highlight that, due to the closure of schools and rehabilitation centers, staying at home has made the period even more challenging for individuals with special needs and their caregivers. For individuals with disorders such as autism spectrum disorder or mental disabilities, online learning environments are often inadequate. Moreover, homes do not have the appropriate structure to promote a healthy and active stay for these individuals.

A concern expressed by Yarimkaya and Esenturk (2020) is that sedentary lifestyles and low social interaction have adverse effects, particularly on the health and quality of life of children with disabilities and their caregivers, a fact corroborated by the literature (CHEN *et al.*, 2020). As a

suggestion, the authors provide a guide with proposals for physical activities that can be carried out, encouraging parents to engage with their children, keeping them physically active and calm, and allowing themselves gains in physical and psychological health.

Neece, McIntyre, and Fenning (2020) also point out challenges faced by parents due to the loss of essential services, as well as their concerns about the long-term impacts of the pandemic on their children's development. The authors conclude the research by stating that professional support, especially during reopening phases, will be critical for promoting family well-being and child development.

The findings presented by these studies are similar to other recent research on the impact of COVID-19 on families, which reveals that parents with children with disabilities or educational vulnerabilities feel more overwhelmed and affected than the general population (COYNE *et al.*, 2020; MASTERS *et al.*, 2020).

Final considerations

The need for research on the challenges that a global emergency, such as the COVID-19 pandemic, brings to education is evident, as educational institutions and teachers are still adapting to this new reality. Furthermore, we still know little about the potential impacts of these new challenges, which reinforces the need for studies on the topic.

In this study, 1,664 articles from 329 different sources were found for the period from 2019 to April 2021. A difference from previous studies lies in the quantity of publications found with the selected descriptors and the type of publications, given that the descriptors were broader and avoided restrictions in the search. Additionally, although only the first four months of 2021 were considered, this year accounts for nearly 40% of the publications found. Thus, the present research, besides being broader in terms of descriptors, also allowed for a greater temporal reach.

The research is also relevant in pointing out the journals with the greatest impact, with a little over 10% of the sample articles published in the Journal of Chemical Education. This was reflected in the co-citation clusters, with the second largest cluster related to chemistry education. Furthermore, three of the ten journals that published the most articles from the sample are in the field of medical education, which may help explain why two of the six most cited groups of articles are directly related to this area.

Another relevant piece of information highlighted by this research is the countries and authors that published the most in the field. It is noted that more than half of the research in the sample comes

Education in pandemic times: a bibliometric analysis of the scientific production on the topic from six developed countries (United States, United Kingdom, Spain, Australia, Canada, and Germany), with researchers from the United States publishing more than a fifth of the papers (27.40%). This information, combined with the fact that few articles are from researchers in Africa and Latin America, may indicate that we still know little about the impacts of the pandemic on education in poor or developing countries.

The co-citation networks also provided insight into some common themes researched. Analyzing the co-citation networks, it is possible to highlight the results of a cluster that addresses the differences between well-planned online learning experiences and online courses offered during crises. These studies show that the COVID-19 pandemic may have accelerated the adoption of online courses without fully utilizing their benefits.

Regarding content analysis, the most cited articles were distributed into six categories: challenges and adaptations of teachers, students, and educational institution administrators during the pandemic; concerns, preferences, attitudes, and opinions of medical students regarding the COVID-19 pandemic and its consequences; impacts of the pandemic on medical education and strategies to maintain teaching in the field during this period; teacher training during the pandemic; adaptations to anatomy teaching in response to the pandemic; and the effects of the pandemic on individuals with special educational needs and their caregivers. In summary, the most prominent theme in the analyzed articles, according to word frequency, was online learning, particularly related to higher education in the medical field.

Considering the analysis of trends and the topics of the articles presented in the results, we agree with Gläser *et al.* (2017) in stating that the role of bibliometricians is not only to extract bibliographic data and discover the topics that 'are in the data,' but to actively construct them based on decisions made in selecting algorithms, descriptors, and the quantity of covered works.

In this aspect, it is also important to point out that bibliometric approaches naturally have limitations. One of them is the possible exclusion of journals and publications that may be present in other databases. However, the goal of this research was to provide a general description of publications on education during the pandemic period. Therefore, specific omissions should not alter the broader picture intended to be illustrated through the research. Furthermore, to minimize the effects of this limitation, a broad database was used, considering the field of educational research in its categories.

This study may be useful for researchers in the field of education and educational policymakers, assisting them in understanding 1) the necessary demands in emergency contexts, especially

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concerning Higher Education; 2) main authors, institutions, research groups, and recurring themes in the field; 3) new teaching proposals with evidence of functionality and what can be done to advance in applying these new proposals in various contexts; and 4) identifying trending topics and gaps to propose new research involving remote teaching scenarios.

This study also reinforces the growing recognition that education plays a significant role in society and that remote teaching, in particular, should be continually refined and constantly evaluated, so that learning objectives are achieved with higher quality, including in future social isolation contexts.

Tendo em vista o quantitativo de produções voltadas especificamente para o higher education, os resultados também podem ser usados diretamente por colegas de cursos dessas instituições, no sentido de sugerir novos métodos de ensino, avaliar a qualidade das estratégias empregadas e influenciar novas proposições.

A possible perspective for future research could involve analyzing the long-term effects that the pandemic has had on students, teachers, and educational institutions. Additionally, a gap identified in the studies is related to research addressing the contexts of elementary and secondary education, as well as schools in rural areas—important aspects in the educational field in our country.

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