International Journal of Instruction *April 2022 ● Vol.15, No.2*
e-ISSN: 1308-1470 ● www.e-iji.net *p-ISSN: 1694-609X*
pp. 37-60

Article submission code: 20210514113736
Received: 14/05/2021 Revision: 14/09/2021
Accepted: 07/10/2021 OnlineFirst: 02/01/2022

The Negative Effects of Technology on Education: A Bibliometric and Topic Modeling Mapping Analysis (2008-2019)

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This study aims to analyze the scientific research that has addressed the negative impact of technology in the educational field. The research is implemented from a methodological approach based on the bibliometric mapping of the scientific production registered in the Web of Science in the period 2008-2019. To do this, indicators of growth, production, impact, topics, keywords, journal references, and analysis of co-citations of authors and co-authors are analyzed. This bibliometric approach is complemented by the analysis of the density, frequency and degree of centrality of the main terms associated with the difficulties and problems of technology in education located in the abstracts and discussion of results in the period 2016-2019. For this purpose, graph theory is developed, using the sigma, cytoscape and graphology libraries. The results show that, among the most common disadvantages linked to the use of technology in education, are: privacy problems, discerning reliable and relevant information, the time required for the preparation of educational materials, the negative impact on academic performance of the students, the lack of resources for its implementation in the classrooms and the infoxication. Finally, it should be noted that in the last three years, the negative impact of technology in the psychosocial field and its impact on teaching-learning processes are beginning to be analyzed in greater depth.

Keywords: disadvantages, problems, technology, education, bibliometrics

INTRODUCTION

Information and communication technologies (ICT) are causing great changes in the Knowledge Society and, therefore, in the teaching-learning process which, among other

Citation: Vázquez-Cano, E., Parra-González, M.ª E., Segura-Robles, A., & López-Meneses, E. (2022). The negative effects of technology on education: a bibliometric and topic modeling mapping analysis (2008-2019). *International Journal of Instruction*, *15*(2), 37-60. https://doi.org/10.29333/iji.2022.1523a

aspects, allows for lifelong learning through the use of tools connected to the Internet and social networks. Although, in general, these changes have brought about important social, professional and educational advances, they also present certain disadvantages that cannot be ignored, and knowing and analysing them allows us to advance toward a more sustainable and adequate use of technology in our lives and, particularly, in the field of education. Among its advantages, ICTs provide the possibility of accessing, sharing and processing data, even remotely and in real time (Duran et al., 2019), generating new ubiquitous communication sets and thus creating new, much richer learning environments and different collaboration spaces (Fernandez-Robles, 2017). Moreover, ICTs are accessible, instantaneous and we use them daily in our lives (Parra-Gonzalez et al., 2020; Sharkova, 2014; Vázquez-Cano, 2014); they influence the way in which we access and use information and, consequently, how we learn (Hoadley & Kali, 2019). To sum up, their impact affects all social scopes, especially the educational scope. In the action framework of the 2030 Agenda, the United Nations (UN) endorsed that young people must adopt flexible aptitudes and competencies that will be useful throughout their lives, considering a world that demands greater sustainability and interdependence based on knowledge and the use of technology (Beltran-Llavador, 2015). Similarly, educational policies advocate, with an increasing trend, for the use of technology as a vehicle of contents and competencies in all educational stages (Vazquez-Cano et al., 2020). In this sense, the unstoppable explosion and expansion of knowledge requires lifelong learning as a basic requisite for personal and professional development, where the use of technology operates as a powerful catalyser (Gonzalez-Sanmamed et al., 2020; Leví-Orta et al, 2020; López-Meneses et al., 2020).

Nowadays, the technological resources used in the digital ecologies of learning have generated a series of benefits and potentialities with respect to the traditional methods of content transmission, as they allow for a greater access to knowledge and more collaborative methodologies, attending to the characteristics of each individual and potentiating the autonomous learning of students (Aguaded & Tirado, 2010). They also promote the increase of student motivation with their increasing availability in learning, as they integrate technological resources inside and outside of the classroom (Laskaris et al., 2017). Likewise, with the new social networks in the curricular praxis, new learning contexts and content repositories are offered as collaborative spaces that show the development of the creativity of their users (Lopez-Gil & Bravo, 2019), and allow improving the dynamisation of learning (Harris & Rea, 2019), acquiring basic competencies (Paramio et al., 2018), obtaining high indicators of efficacy of the process, facilitating the shared creation of knowledge through learning communities (Romero & Patiño, 2018) and initiating a relevant pedagogical change in learning scenarios (Cabero-Almenara & Barroso-Osuna, 2018). Similarly, educators have detected great educational possibilities in these technological innovations to achieve the dynamisation, improvement and upgrade of the teaching-learning processes, which can help to improve, in many cases, the satisfaction, motivation and self-esteem of teachers (Domingo-Coscollola & Marques-Graells, 2011). Therefore, it can be inferred that technology often has a positive impact on the teaching-learning processes and will continue to do so (Tondeur et al., 2016).

However, the influence of technology on education is not always beneficial; in some cases, it can involve elements of discrimination and exclusion in certain social and educational contexts (Cabero-Almenara & Barroso-Osuna, 2018). Likewise, the excessive use of the Internet may have detrimental consequences in the personal and academic life of students. In this sense, the scientific literature provides evidence of the behavioural predictors and alterations associated with an excessive use of the Web, such as guilt, an intense desire of being or continuing to be connected to the Internet (addiction), loss of control, waste of working or lecture hours and increased distraction (Gracia et al., 2002), psychopathological symptoms, significant unrest in the individual (Kilic et al., 2016), distancing from healthy activities and physical personal relationships, greater consumption of biased information and political polarisation (Mosquera et al., 2018). Similarly, Plaza de la Hoz (2018) highlighted the waste of time as a disadvantage, which can be caused by an inappropriate use of technology or ignorance; this author also pointed out the excessive dependency on electronic devices and the insecurity that users may develop when these technologies are used in the wrong way by them or by other people. ICTs also promote high degrees of distraction, among both teachers and students. In this sense, a study led by researchers of Stanford and the University of New York (Allcott et al., 2019) asked a sample of 2,844 Facebook users to deactivate their accounts in this social network for one month. The results showed that quitting the social network involved greater rates of subjective wellbeing, less tension in political topics and stimulation of the attention span, as well as a logical increase of the time they dedicated to their friends and relatives and a lower dependency on digital devices. Likewise, in the educational scope, the constant use of these type of social networks and related technologies has been associated with worse academic results among students (Junco, 2012).

A recent meta-analysis conducted by Huang (2018) has also shown that the intensive use of social networks among students is negatively correlated with the academic results. It seems evident that a non-sustainable use of technology is beginning to cause serious problems in the attention processes of students inside and outside of the classroom, i.e., a disruption that affects their academic performance (Uzun & Kilis, 2019). Thus, different studies show that, in face of the diversity of multimedia sources and formats, the rates of self-regulated learning decrease and generate confusion among students (Lange & Costley, 2019). The literature differentiates the possible adverse effects, not only by the time of use, but also by the type of applications, programmes and actions performed in the Web. In this sense, different studies have shown that texting and social networks are more detrimental to academic performance, since they increase anxiety and reduce concentration, thereby causing great disruption (Lepp et al., 2015). The excessive use of videogames is also associated with poorer academic performance (Jackson et al., 2011) and, for example, other studies (Vázquez-Cano et al., 2020) show that "playing online games via social networks" and "uploading your own created contents" affect negatively to the development of reading competence in young people.

METHOD

Material and methods

This study is approached from an analytical process of systematic bibliometric mapping in one of the most used scientific databases in the academic community: Web of Science (WoS / Core Collection). For this purpose, the total number of documents analyzed was 3,975 between 2008 and 2019. The investigation had two main, well-differentiated objectives. On the one hand, it was aimed at conducting a bibliometric mapping of those articles that address the disadvantages of the use of technology in education; on the other hand, through text mining and the methodological approach of graph theory, the study was also focused on detecting the most common problems associated with the use of technology in education. To this end, the process displayed in Figure 1 was followed.

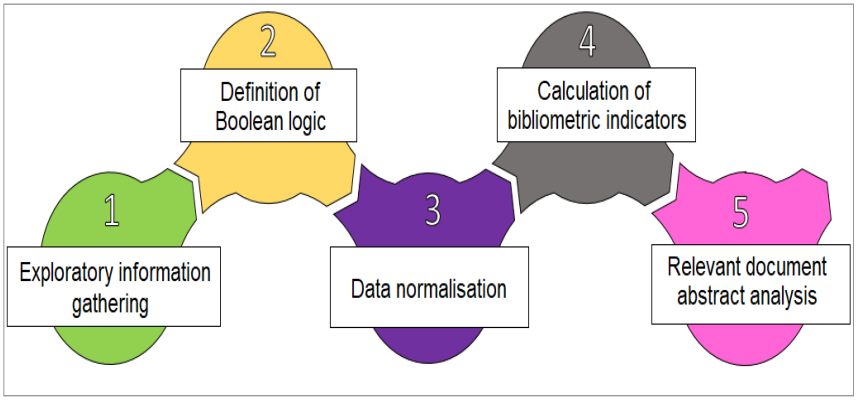

Figure 1
Bibliometric mapping process

Phase 1. Exploratory information gathering

To carry out the different searches, two basic aspects of bibliometric analyses were applied: the establishment of criteria to determine the documents to be included in the different analyses and the exclusion criteria: (1) Studies about educational technology that detect disadvantages in its use. (2) Peer-reviewed articles indexed in the Core Collection of WoS. (3) Documents published between 2008 and 2019. (4) Categories: "Education Educational Research" and "Education Scientific Disciplines".

On the other hand, the exclusion criteria were the following: (1) The term "disadvantaged" understood as a disability. (2) The term "mathematical problems" AND (3) Grey literature, reviews, editorials, etc.

Phase 2. Definition of Boolean logic

The search of the analysed documents was conducted in the Core Collection of the Web of Science. To guarantee the attainment of results with relevant and quality information, the search strategy was previously tested to verify its efficacy. The search terms were

established around three dimensions: "ICT", "learning" and "disadvantages"; (((ict OR technolog* OR Information and Communication Technology) AND (learning OR education OR e-learning OR elearning) AND (disadvantages OR problem*))) NOT (mathematical problems OR problem solving), for the period of 2008-2019.

Phase 3. Data normalisation

Once the data were obtained, they were normalised in order to load them to the different analytical tools used. The different information packages were downloaded and filtered manually; then, the information in rich text format was incorporated for the subsequent creation of the data matrix.

Phase 4. Calculation of bibliometric indicators

During this phase, the indicators of scientific growth and production of journals and authors were calculated. Moreover, the journals with greater production accumulation are presented, as well as their impact on the scientific community. According to Bradford (1985), journals can accumulate in different areas depending on their relative importance within a specific field. The most relevant journals accumulate in the first area, known as the nucleus. This procedure, for instance, is used by the WoS itself to establish their quartiles around the different areas. Likewise, in addition to the previous analyses, co-citation analyses were also applied, analysing references, journals and authors. This type of analysis explores the simultaneous citation of two elements (article, journal or author) by a third document (they appear together in the reference list of other documents). This mechanism divides the bibliometric material in groups, through a network analysis, which allows visualising and analysing the relationships, characteristics, structures and development of a field. To this end, open-code library Biliometrix on R platform and VosViewer were used for the bibliometric analysis and for the construction and visualisation of bibliometric networks, respectively.

Analysis of keywords and topics

A topic analysis was conducted based on keywords. The purpose of this type of analysis is to find correlations between the keywords of the analysed articles, using a co-word analysis. The aim of this analysis is to study the most relevant topics in certain time points of their evolution and predict the most current themes and their direction in the following years. To carry out these analyses, VosViewer was applied, in order to detect the possible main categories. Then, the content of the abstracts and result discussions of the articles published in the period of 2016-2019 was analysed. For this analysis of the content and its main relationships, the InfraNodus software was used. This tool uses graph theory instead of probability distribution to identify the words that are related and assign them to thematic groups.

The text is then converted to a directed network graph. The normalised words (mottos) are the nodes in the network graph and their coincidences are the edges. This application of graph theory helps to better understand the structure of the textual discourse of the interaction between the adverse effects of technology in education, identifying the semantic structure of the relationships between the articles, the results and their

scientific discussion. The quality of the analysed documents is presented or pre-set by different factors. Although WoS already establishes these factors (journal impact, number of citations received, H-index, G-index, etc.) and they are the ones used throughout the present study, it is important to consider the significance or real contribution of certain relevant studies about a specific topic.

FINDINGS

Growth indicators

There is a much more significant growth, from 184 documents in 2008 to a total of 438 documents in 2018. These results represent a 238% increase for the entire period. This difference is more pronounced in 2017, with a 251% increase with respect to the first year of the analysed period. The total number of documents was 3,975 after the search filtering, with an annual growth of 7.74% (Figure 2).

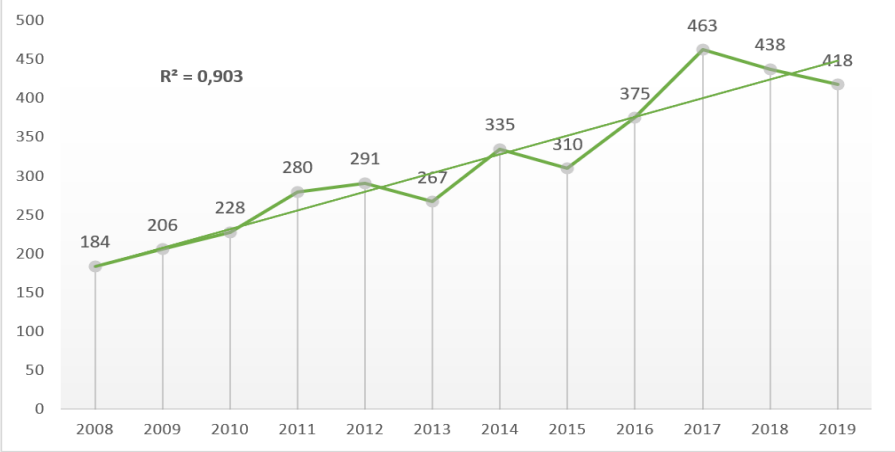

Figure 2
Diachronic growth of the analysed literature

Indicators of production and impact

The production of the authors was measured according to the number of scientific documents generated. The obtained data confirm the presence of the premise proposed by Lotka (1926), few authors accumulate a significant number of publications. The model also shows a correct calibration, explaining in 94% the variability of the axis and in proportion to the mean (R2 = 0.94). In other words, the trend indicates a large number of documents corresponding to a small number of authors. The most productive authors, for the study period, were Hwang G.J. and Huang Y.M., who are also the authors with the greatest and most stable production of documents, with a total of 30 and 12 publications, respectively.

There were 19 nuclei for the analysed scope, followed by zone 2, where 85 journals accumulated; finally, 470 journals fell within zone 3. Specifically, the five most relevant

journals are: "Information technologies and learning tools", "Computers & Education", "International journal of emerging technologies in learning", "Science and education" and "International journal of engineering education".

Analysis of topics and keywords

Figure 3 shows the results obtained after conducting the analysis of topics and keywords. As can be observed, three well-differentiated blocks were detected. In the first block, comprised between 2011 and 2014, the most used keywords were related to the most technical parts of technology ("software", "networks", "support", "web", etc.). In the second block, comprised between 2014 and 2017, the knowledge, beliefs and value of educators and students becomes relevant for the analysed literature. Lastly, another block was found between 2016 and 2019, which contains the most recent publications and in which the main themes revolve around the integration of technology in schools, new methodologies and new problems, such as addiction and depression.

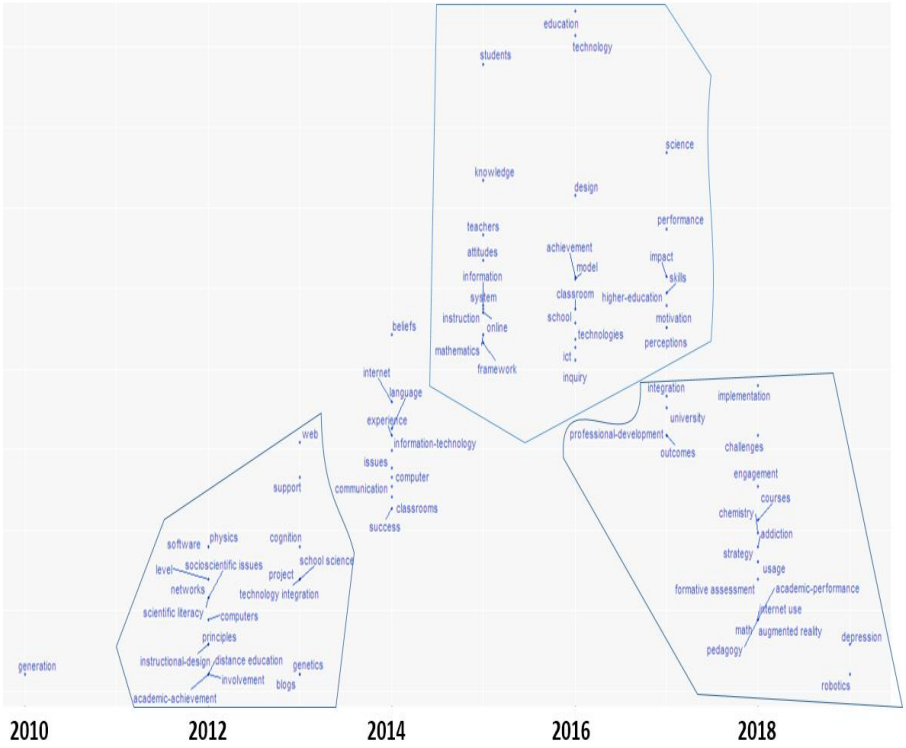

Figure 3
Themes grouped around keywords as a function of the publication year

This study also included the analysis of the co-occurrence network from a general perspective. The size of the box containing the words represents its relevance, the

centrality or periphery represents the position, and the strength of the relationships is shown by the intensity of the colours of the associations. As in the previous analysis, three large blocks were detected, represented in three different colours: blue, red and green. Figure 4 shows that the problems and disadvantages of technology in education (represented by the concepts in red) revolve around their supposed methodological effectiveness and the difficulty to implement evaluation processes in all educational stages. The green associations represent difficulties and problems in the implementation of technology in higher education, e-learning or distance learning, whereas the blue associations show that collaborative and problem-based learning cannot always be approached in an effective manner with the use of technology.

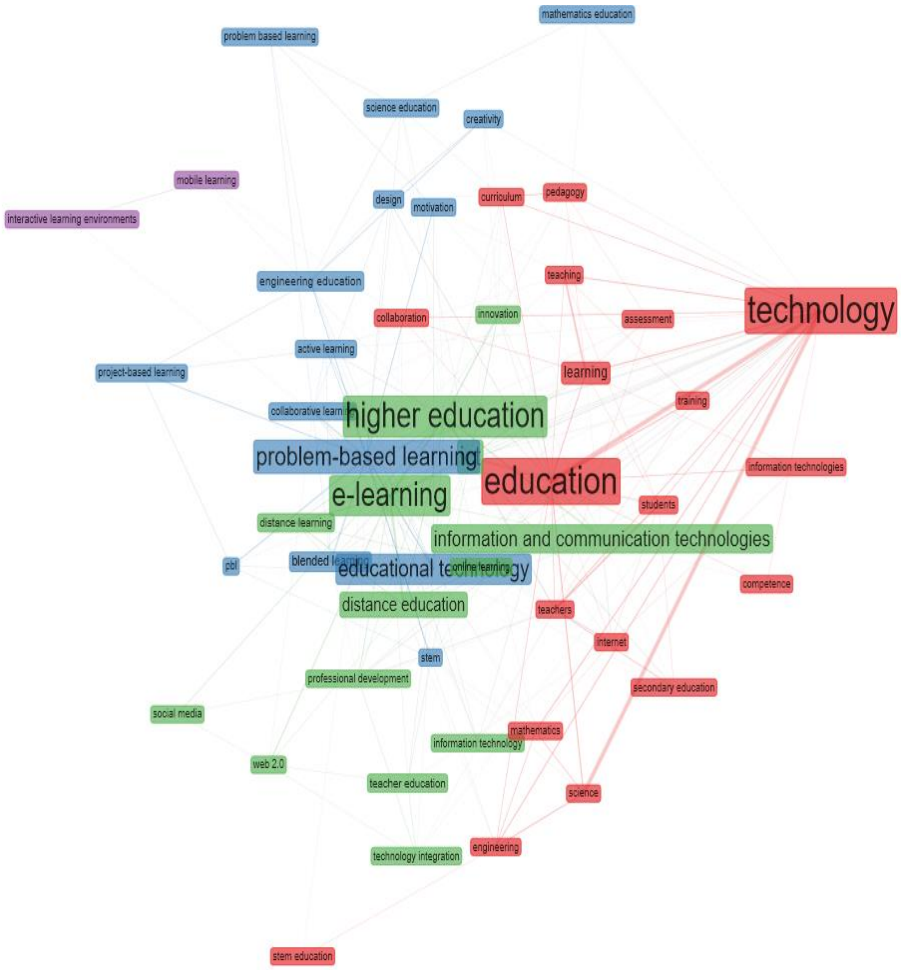

Figure 4
Co-occurrence network

Reference, journal and analysis of author co-citations

Regarding the network of references of co-citations of the analysed articles, the nodes represent the connections between the different articles, showing the research themes that are strongly related to the analysed topic: in this case, problems and disadvantages detected in the use of new technologies in the field of education. Figure 5 presents the cluster analysis, which shows that two articles, published by Vygotsky and Yin, with a total of 38 and 41 citations, have the strongest associations: 527 and 180, respectively. None of these two authors is responsible for the 20 most cited articles for this topic. In the next cluster, there are two articles of Hmelo, with a total of 39 and 22 citations and an association strength of 463 and 150, respectively. Similarly, none of these authors was among the most cited in this topic.

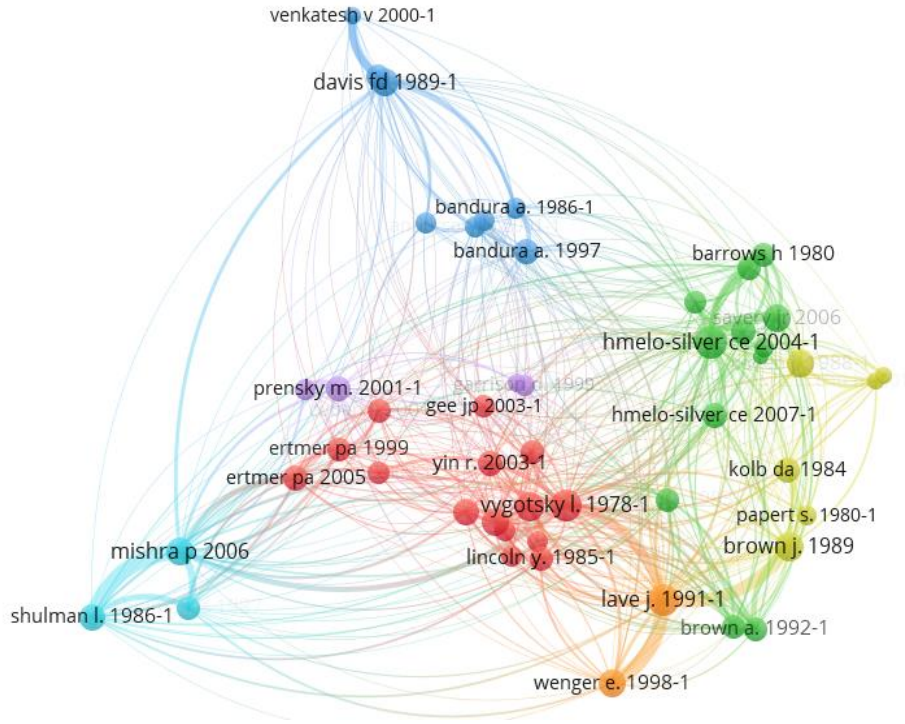

Figure 5
Analysis of co-citations in the documents about technology and its problems

Analysis of the disadvantages detected in the specific literature

After the analysis of the available literature from a bibliometric perspective, the most relevant or recent documents were further analysed (period of 2016-2019). Table 1 shows the semantic analysis of the density, frequency and degree of centrality of the main terms associated with the difficulties and problems of technology in education found in the abstracts and result discussions in the period of 2016-2019.

Table 1
Mapping of abstracts and result discussions

Node	Degrees	Frequency	Intermediation	Topic	Conductivity	Locality	Diversity
Handwriting	88	182	0.384500	2	43.7	2	21.1
Access	66	91	0.337588	6	51.1	301	37.1
Time	86	100	0.133457	3	15.5	6	13.3
Infoxication	78	102	0.130782	0	16.8	5	12.8
Academic Perf.	46	61	0.077589	1	16.9	3	12.7
Ciberbullying	39	56	0.071377	6	18.3	2	12.7
Distraction	37	38	0.019499	0	5.3	257	5.1
Cheating	29	38	0.017988	0	6.2	5	4.7
Insufficient Teach. M.	35	46	0.015962	3	4.6	8	3.5
Disconnection	18	22	0.015872	6	8.8	2	7.2
Oral commun.	31	29	0.013105	4	4.2	7	4.5
Privacy	31	24	0.012697	1	4.1	8	5.3
Manage data	22	26	0.012697	6	5.8	245	4.9
Expensive	27	41	0.012607	3	4.7	6	3.1
Dehumanizing	33	58	0.011972	2	3.6	9	2.1
Isolation	27	31	0.006666	1	2.5	11	2.2
Waste of time	7	8	0.004716	5	6.7	1	5.9
Pornography	16	13	0.002721	4	1.7	9	2.1
Accessibility	24	19	0.001995	5	0.8	129	1.1
Digital divide	28	22	0.000453	0	0.2	173	0.2
Plagiarism	7	4	0.000431	1	0.6	11	1.1
Assessment	32	32	0.000272	6	0.1	376	0.1
Coop. work	17	20	0.000181	3	0.1	159	0.1
Competences	6	3	0.000045	0	0.1	109	0.2

Figure 6 shows the graphs and clusters that resulted from the analysis.

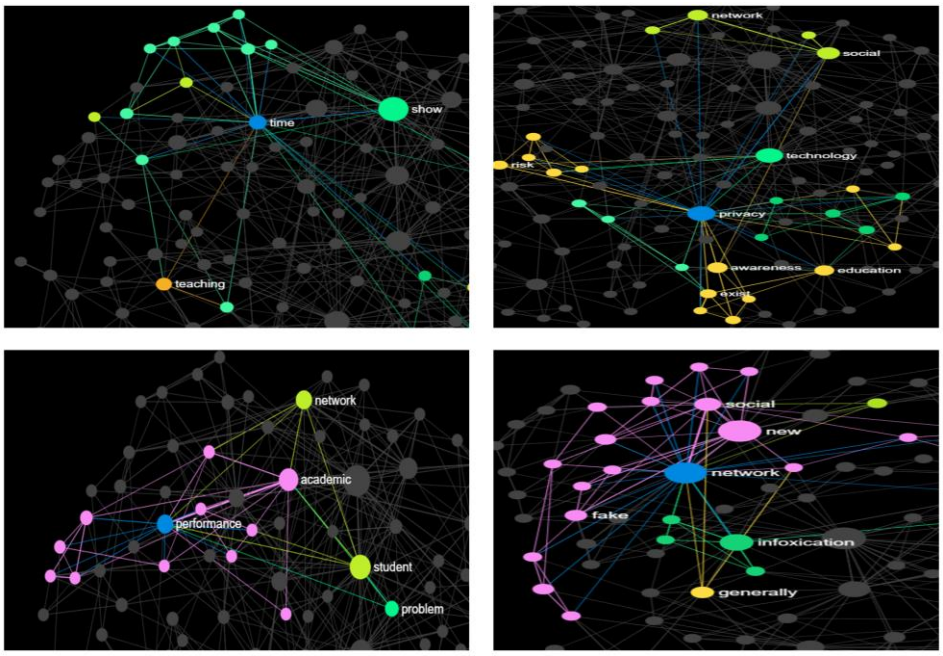

Figure 6
Density graph of the negative impact of technology in education

The degrees of greater centrality that allow connecting the vertices of the words with greater content are concentrated around five problems with degrees of centrality above 0.05 and high conductivity (Privacy 0.544236 / Access 0.221862 / Time 0.190005 / Infoxication 0.183249 / Academic Performance 0.169970).

The main blocks of words detected in the bibliometric mapping identified the chatbots associated to nodal words such as "learning", "task", "interest" and "language". To determine the degree of concordance, we used a PDSM (pairwise document similarity measure) with Euclidean distance. For this purpose, we have grouped the 37 articles and proceedings in three subsets: D^{P1}Abstracts, D^{P2} Results and D^{P3} Discussion; within each group we have grouped the text-subsets D^{P123n} The comparison criterion is established according to the following formula:

$$D_{1}^{C}{}_{\in} D^{C}$$

where index $I \in \{1 \ldots |DC|\}$ we define D^{C} by topics discovered using latent Dirichlet allocation or LDA (Blei et al, 2003) and a pairwise distance matrix. For this purpose, given a discourse text with *m* sentences (without the same sentence repeating), a pairwise distance matrix can be computed by aligning the pairs of all sentences. The computation of this matrix is done only for the lower triangular values and then reconstructed to form the full matrix. The values are all normalised between zero and

one, so that it can be treated like a probability of semantic match. We used a pairwise document similarity measure PDMS with Euclidean distance applying the following equation:

$$PDSM\ (d_1, d_2, d_3)\ = \left(\frac{d_1 \cap d_2 \cap d_3}{d_1 \cap d_2 \cap d_3}\right) \times \frac{PF\ (d_1, d_2, d_3) + 1}{M - AF\ (d_1, d_2, d_3) + 1}$$

The intersection and union of the abstract, results and discussion of the articles are calculated as follows ($w_{ji} > 0$ is the *i*th weight in document *j*):

$$d_1 \cap d_2 \cap d_3\ = \sum_{i=1}^{M} Min\ (w_{1i}, w_{2i}, w_{3i})$$

The results of the comparisons and similarities found in abstracts, results and discussion are presented in the pairwise distance matrix (Figure 7).

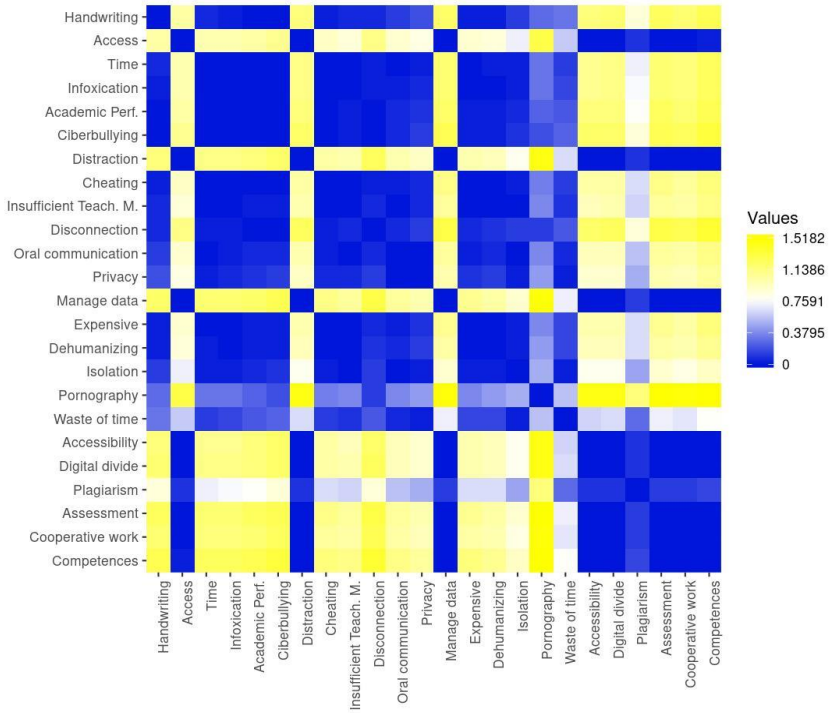

Figure 7
Pairwise distance matrix

Likewise, to complement the cluster information, we analyzed the bigrams associated with each of the clusters in order to go further into the relationships between concepts and their impact on learning. To do this, we used the following notation.

```
bigram_tf_idf <- bigrams_united %>%
  count(cluster, bigram) %>%
  bind_tf_idf(bigram, cluster, n) %>%
  arrange(desc(tf_idf))
```

We present, in Table 1, the "td_idf" with the highest results of the three most representative bigrams in each of the clusters in order to determine their educational functionality in the three areas of "second language learning", "study performance" and "conversational interaction".

Table 2
Cluster bigrams

Cluster	bigram	n	tf	tf_idf
second language learning	teach-writing	21	0.01984481	0.04249422
	improve-language use	33	0.01864482	0.02849211
	enhance-critical thinking skills	24	0.02684118	0.04241460
study performance	promote-engagement	43	0.02612241	0.04129641
	foster-motivation	51	0.02984499	0.04249464
	promote-memory retention	37	0.02046901	0.04124662
conversational interaction	develop-participation	48	0.02240641	0.02086241
	guarantee-feedback	35	0.02882462	0.04966412
	social interaction-among peers	33	0.02664289	0.04129866

In Table 2, we can observe that the first cluster "second language learning" is divided in three bigrams: (1) "teach-writing" (tf_idf 0.04249422); (2) "improve-language use" (tf_idf 0.02849211) and (3) "enhance-critical thinking skills" (tf_idf 0.04241460). In this sense, the use of chatbots can help students to develop important dimensions of second language learning by improving improve student learning-to-write engagement and enhance the participation in the language use along with the application of critical thinking skills. The second cluster "study performance" is divided in three bigrams: (1) "promote-engagement" (tf_idf 0.04249464); (2) "foster-motivation" (tf_idf 0.04249464) and (3) "promote-memory retention" (tf_idf 0.04124662). The study performance with the use of the chatbots is accomplished by the promotion of the engagement and motivation and the promotion of a more deeper memory retention than with other digital tools or didactic approaches. Finally, the third cluster "conversational interaction" is divided in another three bigrams: (1) "develop-participation" (tf_idf 0.02086241); (2) "guarantee-feedback" (tf_idf 0.04966412) and (3) "social interaction-among peers" (tf_idf 0.04129866). One of the most important features related to the educational use of chatbots is the possibility of interacting with the machine and among peers and receive constant feedback. This "conversational interaction" can be promoted any-time any-

place due to the possibility of using chatbots in digital devices from a mobile and ubiquitous perspective.

DISCUSSION

As was observed in the results, there were five difficulties and problems with greater influence on education in the last three years. In this section, these five problems are discussed: privacy, access to technology and digital divide, the need of time to prepare digital activities, infoxication and the possible negative impact of technology on the students' academic performance. First, with the prevalence of intelligent devices and access to the Web, privacy has become an essential aspect in governmental, academic and technological matters (Katherine-Chen & Ryan-Wen, 2019). In this sense, Europe classified the main risks for minors, including the risks associated with privacy (e.g., services that use geolocation). Regarding privacy, several studies demonstrate the negative impact that the use of technology can have on people's rights, especially on minors' rights. Demertzis et al (2021: 120), point out that "with a small exchange: they know who we are, when is our birthday, what are we searching for online, our employment, where we have been, what our faces -and those of friends and relatives- look like, what we believe in, even our political views (Curran, 2018; Smith, 2020; Nield, 2019; Norval & Prasopoulou 2017)."

Rodríguez-García and Magdalena-Benedito (2016) warned about the lack of awareness and the need to be aware about the problems that the wrong use of technology can cause for the privacy and image of the people. Likewise, different investigations suggest raising awareness about privacy through cooperation with social media, disseminating advices or recommendations in the educational scope. Moreover, there are few studies about how to adequately use the large amount of privacy controls that exist and how to properly apply them in the field of education (Wisniewski et al., 2017). In this sense, Gogus and Saygin (2019: 2) show that educational applications that collect users' information present the opportunity for students' data to be mined. Furthermore, the neuromarketing techniques or the automated bots may contribute to reduce students' privacy in educational activities (Shorey & Howard 2016). Lastly, among the conclusions proposed by Livingstone et al. (2009), these authors showed that the mediation of educators is the first determining factor to reduce the potential risks involved in the use of technology. Second, the digital divide is often characterized as a digital divide cascade which is nuanced into different types of inequalities including unequal capabilities, engagement, and use outcomes in addition to inequalities of access and use (Vassilakopoulou & Hustad, 2020: 5). The data of the "EU Kids online" report (Livingstone et al., 2009), about the adoption of technologies in Europe, shows that, in the early 2010s, children connected to the Internet every day from different devices (especially smartphones) at an increasingly younger age. This trend continues and has increased in the late 2010s. Likewise, the offer of apps for children in the stage of early childhood education has increased considerably, reflecting the growing demand from educators and families for digital resources that help children to learn and play (Troseth et al., 2016). In this sense, Céspedes-Ventura and Ballesta-Pagán (2018) found that primary education centres are sufficiently equipped with fixed devices, although they

pointed out that these centres do not have portable digital devices, which largely limits the capacity to implement adequate methodologies in these educational stages. But this situation is not the same in all the countries and continents, about 56 million learners live in locations not served by mobile networks, almost half in sub-Saharan Africa and the COVID has worsened this digital gap, globally, at least 1.5 billion students and 63 million primary and secondary teachers are affected by the unprecedented disruption caused by the COVID-19 pandemic, with school closures in 191 countries Teachers also require training to deliver distance and online education effectively, but such support is particularly scarce in low-income countries. Across sub-Saharan Africa, just 64% of primary and 50% of secondary teachers have received minimum training, and this frequently does not include ICT skills (UNESCO, 2020).

In this sense, we can identify two problems with the digital divide: access and use (competence) (Bucea et al. 2020). For this, the digital divide has to be approached from a comprehensive model (Choudrie et al. 2018) in which psychological, educational and socio-economical variables have to be considered (Ebermann et al. 2016; Fox & Connolly 2018).

Furthermore, the use of technology in education requires in most cases a considerable investment of time. The design of activities based on technology not only requires competence and knowledge in the tools to be used, but also a time commitment that not all teachers have. The Education and Training Monitor (2020) derived from the OECD Teaching and Learning International Survey (TALIS, 2018) indicates that the use of information and communication technology (ICT) for teaching was rarely included in the education and training of lower secondary teachers in EU countries. On average in the Member States, fewer than half of teachers (49.1%) report that ICT was included in their formal education or training. Teaching has been traditionally based on a teacher-centred methodological model, with an emphasis on the transmission of contents and their reproduction by the students, master class and individual work. Nowadays, teaching through technological resources involves the need for a new approach based on the education of competencies and enough dedication and time to adequately integrate it in the teaching-learning processes (Aguaded et al., 2010). Regarding the preparation time, the results show that the implementation of didactic processes based on technology requires specialised training and longer time to prepare the activities and their corresponding evaluation (John, 2015). This situation is even more relevant for older teachers, and in the Education and Training Monitor (2020), teachers' sense of preparedness for the use of ICT for teaching is related to the year of completion of their formal education or training. A higher percentage of teachers who completed their formal education or training in the 5 years prior to the TALIS survey felt well or very well prepared to use ICT for teaching. In this sense, teacher training systems must be implemented in order to allow updating in basic digital teaching competencies for the development the curriculum and for optimizing the time that teachers need to dedicate to the preparation of activities based on technology.

Another problem associated to the use of technology in Education is the infoxication (misinformation, disinformation and fake news). In fact, by 2025, it's estimated that 463

exabytes of data will be created each day globally. To put this in perspective, that's the equivalent of 212,765,957 DVDs (IE University, 2020) and among these exabytes who knows what is real of fake. As Clarke (2017) writes, the "paradox of the Information Age is that while we have access to many more and diverse information sources, it is getting harder to determine the origin and authenticity of information, to distinguish fact from opinion and truth from lies." The current communication ecosystem has recently undergone abrupt changes, due to which it has become a phenomenon of mediamorphosis almost impossible to understand and analyse, rather than an ordered and structured system. It is important to take into account that a large percentage of the population consumes news in social networks or in websites and blogs without the adequate verification of the contents. In this sense, a high proportion of news that circulate in the Web do not go through rigorous and solid verification processes and could be catalogued as fake news. Thus, if the user does not know that the information is incorrect, its use can lead to an erroneous learning (Talebian et al., 2014). It is necessary to discern the credible and veracious information from the dubious information that is transmitted through social media without the appropriate information verification to avoid infoxication. Moreover, research in this topic demonstrates that the assistance and orientation of the teachers and training in media competence are necessary for the improvement of the personal and academic development of the students (Biddix et al., 2011). From the students' development of competences, it is essential to reinforce the critical thinking skills in order to enable students to engage in purposeful, self-regulatory judgment (Behar-Horenstein & Niu, 2011; Warsah et al., 2021). As Weiss et al (2020: 8) point out, it is necessary to help students to become aware of the powerful social forces at work in the world which serve to silence and marginalize others, restricting human freedom (Davies & Barnett, 2015).

Finally, a controversial aspect is whether technology substantially improves the academic development of students or if the opposite worsens it. There is evidence in both senses in a multitude of articles and research. But the negative or not sufficiently positive effects of technology have been evidenced by projects of recognized prestige such as the one by Hattie (2008) based on meta-analysis with a sample of more than 300 million of students in which technology does not substantially improve the academic development of students with an effect size not higher to 0.40 in most of the cases analyzed. The scientific literature is recently showing that the excessive use of technology can have very detrimental effects on the teaching-learning processes, mainly on academic performance. The main disadvantages revolve around the negative impact of social texting, due to the disruption and distraction it causes in the academic activities inside and outside of the classroom, as well as the reduction of concentration in learning (Huang, 2018). In this sense, the students who take digital devices to the classroom (smartphone, laptop or tablet) have greater levels of distraction, since they constantly check social media and digital content and, therefore, are more likely to obtain worse academic results. This use can also decrease competence in the learning of skills and in self-regulated learning (Gaudreau et al., 2014). Contrary to what the press and the industry have spread so far, the use of technology, far from helping the development of children and students, produces serious complications of all kinds: on the body (obesity,

cardiovascular problems, reduction of life expectancy), on emotions (aggressiveness, depression, risk behaviors) and on intellectual development (impoverishment of language, concentration, memory ...) (Desmurget, 2020). All the pillars of development are affected; from the somatic, that is, the body (with consequences for cardiovascular maturation or the development of obesity, for example) to the emotional (with aggressiveness or depression, among other consequences), passing through the cognitive, that is, the intellectual (with effects on language or concentration, among other aspects). And most likely, all these damages have an impact on academic results. Moreover, it seems that digital activities for educational purposes that are carried out in class are not particularly beneficial either (Desmurget, 2020). In words of Andreas Schleicher (2016) "if anything [Digital] it makes things worse."

CONCLUSIONS

Technological learning, research and innovation are the main axes for the improvement of the quality and competitiveness of countries, along with the sustainable development of their citizens. Thus, it is necessary to define both the strengths and the main controversies and problems derived from the impact of technology on students, teachers and the teaching-learning processes. Only through rigorous analyses, it will be possible to mediate an adequate and productive use of technology in the educational scenario. Firstly, the results of this investigation show that the negative effects of technology on education has become the focus of numerous scientific studies in the last 10 years. The analyses of the present work show five fundamental problems: privacy, access to technology and digital divide, the need of time to prepare digital activities, infoxication and the possible negative impact of technology on the students' academic performance.

Therefore, the thematic approach of the scientific publications about the negative impact of technology on education has ranged from rather technical topics up to 2014 to others based on beliefs and the value of technology as innovation in the period of 2016-2017, and, in the last three years, researchers have focused mostly on problems related to integration, accessibility and the emergence of addiction and depression. The analysis of the negative impact was led by a group of researchers of three different geographic locations: United States, followed by Spain and the United Kingdom. It is important to highlight that the responsibility to educate in avoiding the wrong use of technology cannot be exclusively given to the education system. This issue must be monitored from the research, home and school scopes, given the fact that a greater screen time "does not guarantee the development of a reflective attitude, neither does it favours learning" (Caldeiro-Pedreira & Aguaded, 2017: 102). Thus, "adolescents are required to acquire reflective capacity in order to reach audiovisual autonomy" and "develop a critical view that allows them to survive in a digitalised world."

It is important that the possible adverse effects of technology on education are faced from different training proposals to minimize the negative impact on the teaching-learning processes. It is necessary to implement systems to guarantee the privacy of the students when developing activities that require the use of programs or apps that require the registration of the students, as well as in the use of social networks. It is also crucial to design training programs for teachers in basic digital skills that allow increasing the

capacity to design digital activities, minimizing the time required to carry them out, and assessing the effect to promote higher academic performance of students (Zulfiani et al., 2021). Likewise, understanding the current digital scenario requires teacher and student skills to make a critical and sustainable use of technology, avoiding misinformation and misinformation, as well as infoxication processes. Finally, to avoid the digital divide it is necessary to generate a greater economic investment in infrastructures and devices and face their overcoming from a holistic approach in which individual and social aspects need to be taken into consideration. Therefore, it will be necessary to design study programmes which transversally incorporate subjects related to media literacy that potentiate the competencies of the citizens.

LIMITATIONS

Firstly, the bibliometric process was excessively rigorous, as it was based on very specific information established by a predominant database like WoS. Secondly, the presented analyses could have been expanded to other databases to carry out a combined analysis of the latter. Lastly, the authors point out the need to carry out a thorough analysis of the different disadvantages highlighted in the present study through a systematic literature review.

ACKNOWLEDGMENT

This research has been developed with the support of the I+D+I Project entitled: ‘‘Gamification and ubiquitous learning in Primary Education. Development of a map of teaching, learning and parental competences and resources “GAUBI”. (RTI2018-099764-B-100) (MICINN/FEDER) financed by FEDER (European Regional Development Fund) and Ministry of Science, Innovation and Universities of Spain.

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