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Review

Use of Virtual Tools in Teaching-Learning Processes: Advancements and Future Direction

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Abstract: Teaching-learning processes have been affected by the changes that the introduction of information and communication technologies are making to the current global dynamics. This study examines the trends and evolution of the application of virtual tools in teaching-learning processes. Using a bibliometric analysis, 104 articles retrieved using a search equation defined under the PRISMA methodology were analysed. The results allowed the identification of the most influential contributions, authors, and journals, as well as the trends of research carried out in the field, identifying the authors García-Peñalvo, Sánchez-Prieto and Olmos-Migueláñez as the main references in terms of productivity and impact, as well as the journal Computers in Human Behaviour as the most important in academic impact; additionally, it is identified that COVID-19 and online education are among the main emerging concepts, and higher education and the TAM are among the most solid in the research field. Similarly, the research carried out can be classified into four categories based on their main topic: the acceptance of technology; the design of instruments; the design of platforms; and relevant content. Among the main conclusions, it is mentioned that these tools provide aspects of flexibility, coverage and accessibility at all educational levels.

Keywords: bibliometric analysis; virtual tools; teaching-learning process; PRISMA methodology

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Citation: Botero-Gómez, Vanessa, Luis Germán Ruiz-Herrera, Alejandro Valencia-Arias, Alejandra Romero Díaz, and Juan Carlos Vives Garnique. 2023. Use of Virtual Tools in Teaching-Learning Processes: Advancements and Future Direction. *Social Sciences* 12: 70. https://doi.org/10.3390/socsci12020070

Academic Editors: Roberto Sánchez-Cabrero and Lidia Mañoso-Pacheco

Received: 28 December 2022
Revised: 23 January 2023
Accepted: 24 January 2023
Published: 29 January 2023

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1. Introduction

During the new millennium, a series of tools have been created based on emerging information and communication technologies (ICTs), which have supported the growth and evolution of different areas, as is the case for the development of teaching-learning processes, contributing to education. As such, ICTs have become a new social space (Durán et al. 2015), transforming the classical teaching model by strengthening virtual education through the use of electronic devices that enable access to information (Rodrigues Espinosa et al. 2014).

Virtual learning has allowed people to study from the place and at the time of their choosing, increasing the possibilities that students, who for different reasons cannot attend educational establishments, develop specific knowledge competencies (Durán et al. 2015; Valencia-Arias et al. 2019; Chavoshi and Hamidi 2019). In addition, students of these times have been characterised as effective adopters of ICTs, becoming "active producers of knowledge" (Rodrigues Espinosa et al. 2014; Sánchez-Cabrero et al. 2019a). Similarly, virtual tools have motivated students in the search for knowledge and in the educational process in general (Arango-López et al. 2019; Peña et al. 2018).

Current research focuses on the development of studies on the use of ICTs in education, particularly applications in developed countries, and focuses on the main actors of the

processes, students and teachers, in the advance towards the proper implementation of virtual tools. However, studies in developed countries do not impact emerging countries because of the challenges related to the transfer of knowledge, given the social, cultural and economic differences regarding the acceptance of technology by teachers and students. This can lead to imbalances when analysing aspects such as effectiveness, autonomy, skills and motivation to use ICTs in educational processes between developed and developing countries (Valencia-Arias et al. 2019). Thus, understanding the behaviour and contribution generated by virtual tools in educational environments in different social and economic contexts is of utmost importance because it would favour the growth of research in this field, and would provide educational institutions with alternatives that allow flexibility in training processes and expand academic coverage.

The approach used in the research was based on the development of a bibliometric analysis under the PRISMA methodology because it allows a global overview of the studied context of a specific issue (Pięta 2017; Lai and Bower 2020). In addition, it provides significant data on the most productive and influential topics, authors, countries, journals and institutions, as well as information on the trends and impacts of the topic in a given context (Eshraghi et al. 2013). For this reason, bibliometric studies provide a starting point for research on emerging issues (Gläser et al. 2017). In this way, bibliometrics are used to identify the factors involved in the adoption of virtual tools in the teaching-learning processes, because it allows appropriate access to the context of the study topic.

The revision of the manuscript was self-critical by the authors themselves, in addition to receiving recommendations and observations from experts. On the other hand, the editor's suggestions were essential for the materialization of the manuscript. In this study, a referential framework can be found, together with a virtual educational tools section, where the importance and capacity of ICT to create possible teaching and communication environments is expanded. Additionally, there is the methodology of the construction of the research, as well as the inclusion and exclusion criteria, following the PRISMA methodology, based on the search equation. Going through the approach of the results obtained, there are quality indicators, publications, most representative authors, citation indexes by authors, structure indicators and networks, among others. The discussion is based on the results obtained, collaboration networks between authors, and the concurrence of words from the results. Finally, the study is concluded and highlights the students' increase in their interest and motivation to participate in learning activities.

The above is conducive to having scientific arguments supported by different research questions such as: What are the emerging trends in teaching and learning processes using ICT tools? Which authors are the most recognized and make use of ICT tools and propose academic environments for teaching and learning? What are the categories of study that use ICT in virtual training environments in the teaching of specialised areas, such as engineering? The above will trigger several alternatives that will mitigate the gap in underdeveloped countries concerning the powers in education, making it evolve in teaching and learning environments in the dynamics of teachers, guides or facilitators, in the achievement of different specialised academic competencies.

2. Referential Framework

Virtual Educational Tools

Since the end of the 20th century, the term ICT has become popular and is defined as all technological developments (hardware or software) that allow people to access, produce, store, share, collect, present and transfer information, communicate with each other, or in groups, through electronic devices, telecommunication devices and digital systems. ICTs have been characterised by the possibility of creating communicative and expressive environments that enable the development of new, formative, expressive and educational experiences (Cobo Romaní 2009; Ministerio de las Tecnologías de la Información y las Comunicaciones 2020). These environments, based on the development of virtual tools, are identified as being flexible and easily accessible; that is, users can access them from

mobile devices, such as computers and smartphones, and interact with apps at the time and place they want, eliminating existing barriers, especially in academic environments (Kumar Basak et al. 2018; Peciuliauskiene et al. 2022).

Globally, there is a need to adopt and integrate new technologies in teaching-learning processes to take advantage of the opportunities and challenges that innovation offers to the system (Cabero-Almenara et al. 2019; Sanchez-Cabrero et al. 2019b; Usuga-Escobar et al. 2022). Virtual training environments are virtual social spaces created mainly on the Internet. Their purpose is to offer flexibility, providing the possibility of accessing information at any time and from any place; that is, they are virtual spaces where services and tools are offered that allow the construction of knowledge and cooperation and interaction with other people (Fernández and González 2011). In this way, the application of ICTs in academic environments has made it possible to offer communication options between computer and virtual training environments, providing a set of possibilities of use applicable to both distance education and as well as in-person teaching (Salinas 2005). According to (Dinis et al. 2018), applications such as virtual reality provide new practices that improve the transfer of knowledge and communication between the students and teachers who use them, taking advantage of the interest shown by students in information technologies applied to specific areas.

3. Methodology

The objective of this research is to examine the trends and evolution of the application of virtual tools in teaching-learning processes through the most influential contributions, authors and journals on the topic of study, and to investigate the trends in applying these technologies in academic systems. To achieve this, bibliometric analysis was used. Bibliometry is the science that studies the trends of a specific area of knowledge or discipline through computation and the analysis of facets of written communication (Villa et al. 2018). In addition, it is used to describe, explain, predict and evaluate the academic results retrieved on a certain topic (Borgman and Furner 2002); similarly, bibliometrics allows the study of science through quantitative, qualitative and scientific progress aspects, which become indicators that can describe the behaviour of the theory, field or area analysed (Sancho 1990). To acquire published works on the application of virtual tools in the teaching-learning processes, the SCOPUS database, the largest international academic database and one of the most prestigious, was used. Through the database, queries were made to retrieve reliable and rigorous sources, ensuring the relevance and significance of the knowledge to which there is access and serving as a starting point for this process (Norris and Oppenheim 2007; Valencia et al. 2021).

Thus, bibliometric analysis has proven to be a methodology that allows a quantitative identification of trends and behaviours in a specific area of study through a variety of indicators, depending on the identified factors of interest, for a particular research field (Börner et al. 2003; Kaur and Bhatia 2021). The bibliometric approach is based mainly on the search for the quantitative characteristics of the topic studied; characteristics of research publications, such as article titles, keywords and phrases; authors, including their institutional affiliation, co-authors and reputation; and books and journals, including titles, topics and the country of origin (Gupta and Bhattacharya 2004), allowing the identification of useful patterns for the advancement of research and scientific development (Villa et al. 2018). In addition, secondary indicators can be identified that are associated with the techniques that allow identifying terms and emerging topics and their association with multiple entities, such as countries, regions, organizations and individuals, as well as a series of case studies that explore the empirical perceptions hidden behind the interactions between these indicators and specific emerging sectors (Zhang et al. 2019).

3.1. Inclusion Criteria

Understanding the parameters established by the international PRISMA statement, we have the inclusion criteria that articles must follow to be analyzed within the literature

review process, as evidenced in (Lai and Bower 2020). In that sense, for the present bibliometric analysis, all articles are included that, in their main scientific metadata, relate the terms e-learning, m-learning, virtual or gamification, as well as tools or gadget, to have articles that account for the different virtual tools, and in addition, are related to the keywords of teacher, education, instructor and other synonyms, validated by specialised thesauri such as IEEE and UNESCO, to account for articles that point to the object of study.

3.2. Exclusion Criteria

According to the PRISMA statement, all literature reviews, focused on their own research objectives, must establish specific exclusion criteria (EC) that allow authors to analyse relevant and quality information for their rigorous and investigative purpose (Lai and Bower 2020); therefore, for the present literature review, the following three EC were established:

EC1 = Documents for which there is no access to the full text;

EC2 = Research articles that could be accessed as full text are presented as incomplete articles;

EC3 = Records that, even meeting the two previous criteria, do not have sufficient methodological rigor.

3.3. Information Sources

In this article, a bibliometric analysis was performed on the use of virtual tools by teachers in the management of teaching–learning, based on the data recorded in the academic publications retrieved from the SCOPUS database. The SCOPUS bibliographic database provides tools for information management and meets criteria such as the number of citations and accessibility, scientific recognition, and wide worldwide coverage of specialised texts in the areas of interest, and is also the source of the most used data in this type of analysis and studies in the literature (Michael Hall 2011; Mengual Andrés et al. 2017). In addition to its accessibility, SCOPUS was selected for this study because it is considered a valid, reliable and timely source of academic information and is the largest database of citations and abstracts of peer-reviewed literature and high-quality sources on the web (Cheng et al. 2014; Zancanaro et al. 2015).

3.4. Search Strategy

The search equation for the study was defined by the object of bibliometric analysis; that is, the virtual tools used by teachers in the teaching process. To this end, the key terms equivalent to virtual tools for teaching (virtual tools in academic training – virtual tools in academic training) were considered search criteria, along with terms equivalent to the word adoption (appropriate * - adopt *).

These key terms were searched in the title and keyword fields, with an end date of 31 December 2021. Tests were performed with equation options, which differed from each other in their keywords, the distance between the terms and the scope of the search (between title, abstract, keywords and full text). On the basis of the above, the search equation that best addressed the needs of the study and reported the greatest affinity with the research carried out on the topic was defined:

(TITLE-ABS-KEY (e-learning OR m-learning OR blended AND learning OR gamification OR virtual) AND TITLE-ABS-KEY (adopt* OR accept* OR appropriat*) AND TITLE (teacher OR educator OR professor OR lecturer OR tutor OR trainer OR instructor) AND TITLE-ABS-KEY (tools OR gadget)), allowing the extraction of 208 documents for subsequent analysis and submission to the previously detailed exclusion criteria.

3.5. Data Management

The necessary data for the development of the different indicators were obtained so that they allowed visualising the state of the art through the number and distribution of publications, productivity and collaboration. Likewise, impact indicators were generated

and used to evaluate the impact of authors, articles and journals in a given area (Durieux and Gevenois 2010). Similarly, structure indicators were used to measure the connections between different authors and publications (Villa et al. 2018). Finally, the trends in the study of the explored field were analysed by observing the behaviour of the keywords, allowing the identification of increasing, decreasing and emerging fields in the area (Enciso et al. 2016).

These bibliometric indicators of quantity, quality, structure and research trends were analysed using the Microsoft Excel®office tool that, as identified and applied by authors such as (Martin et al. 2020), is an important tool for the analysis of large-volume data and facilitates data treatment and future submission to reflections, calculations and quantitative synthesis.

3.6. Selection Process

Likewise, in the PRISMA statement reference items, detailed by (Estarli et al. 2016), the processes of creating exclusion criteria (previously detailed), as well as their application in the screening and eligibility phases, must be executed. Initially individually, and subsequently, jointly, to reduce to a minimum expression the bias presented in the application of exclusion criteria, concerning the research's authors. In this case, the differences found in the individual analysis are justified and resolved as a whole, so that the records included are related with the proposed objectives of the research.

Figure 1 illustrates a flow diagram detailing the PRISMA statement; all the steps followed in the present investigation are shown, as well as their specificities in relation to quantities, databases, exclusion and evaluation criteria in quantitative synthesis. Of the 208 records initially retrieved from the SCOPUS database, 104 were subjected to quantitative synthesis, as detailed in the results section.

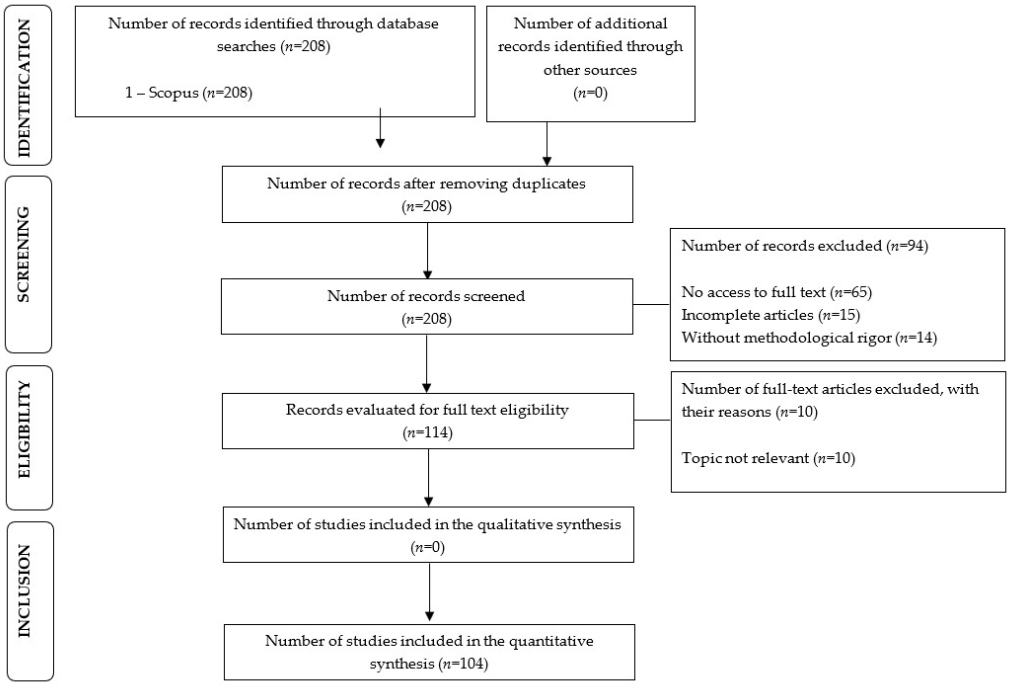


Figure 1. PRISMA flow diagram of identification, screening and eligibility assessment. Own elaboration.

4. Results

In this section, the results obtained during the bibliometric analysis are presented based on the indicators presented in the methodology. For this reason, the information is grouped into four categories, i.e., quantity indicators, quality indicators, structure indicators and trends in the study of virtual tools in the teaching-learning processes.

4.1. Quantity Indicators

The search equation defined by the researchers was used to calculate the quantity indicators for the application of virtual tools in teaching-learning processes.

Figure 2 indicates growth in the number of publications since 2009; the number of documents begins to gradually increase, with a strong increase in publications on the topic of study in 2015 and 2016, retrieving 11 and 12 publications, respectively. Likewise, 2017 and 2019 are the two periods of greatest production, with 19 documents each; however, in 2018, there was a reduction in the number of published scientific studies. In 2020 and 2021, the number of publications related to the use of virtual tools in educational processes increased again, with 14 publications in each period. Given the above, it is evident that research on the application of virtual tools in teaching-learning processes expanded between 2017 and 2021, when the strengths and contributions of virtual tools in processes developed in educational environments began to be identified, not only in basic topics but also in specific areas (Dinis et al. 2018; Krittanawong et al. 2022).

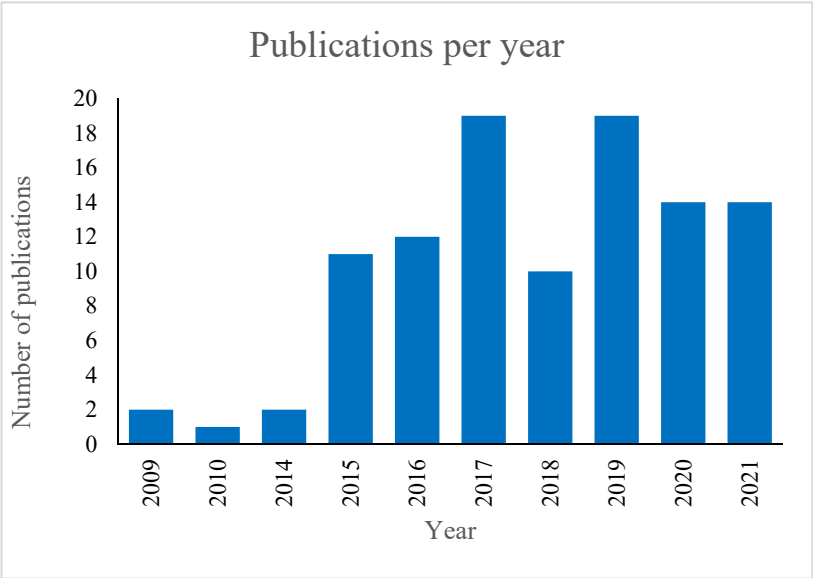


Figure 2. Number of publications per year. Own elaboration from SCOPUS data.

Regarding the journals with the greatest impact in the field, the 10 main journals were selected, chosen based on the number of publications on the application of virtual tools in teaching-learning processes. Figure 3 shows the number of publications per journal.

As seen in Figure 3, 14% of the journals published 34% of the scientific production on the application of virtual tools in teaching-learning processes. "Proceedings of the European Conference on E-learning, ECEL" and "Lecture Notes in Computer Science" were the leading journals in the publication of research on the topic; the first published six articles, while the second published five. Ranking first, the European Conference on E-learning publishes the conference proceedings and presentations highlighted in the event to build networks around virtual education (European Conference on e-Learning 2019). Ranking second, "Lecture Notes in Computer Science" includes two other sub-series called "Lecture Notes in Artificial Intelligence (LNAI)" and "Lecture Notes in Bioinformatics (LNBI)", which publish conference proceedings on works and developments derived from research in areas related to education in computer science and information technology (Springer 2023a). Ranking third, "Advances in Intelligent Systems and Computing" focuses its interest on publications related to the theory, applications and methods of system design and intelligent computing; it covers areas such as engineering, computer science, the application of ICTs, business and medicine (Springer 2023b). Ranking fourth, with three publications, is the journal "Communications in Computer and Information Science", which aims to disseminate works in the entire spectrum of computer science, from fundamental

topics in the theory of computation to science and ICT, as well as the variety of applications at the interdisciplinary level (Springer 2023c).

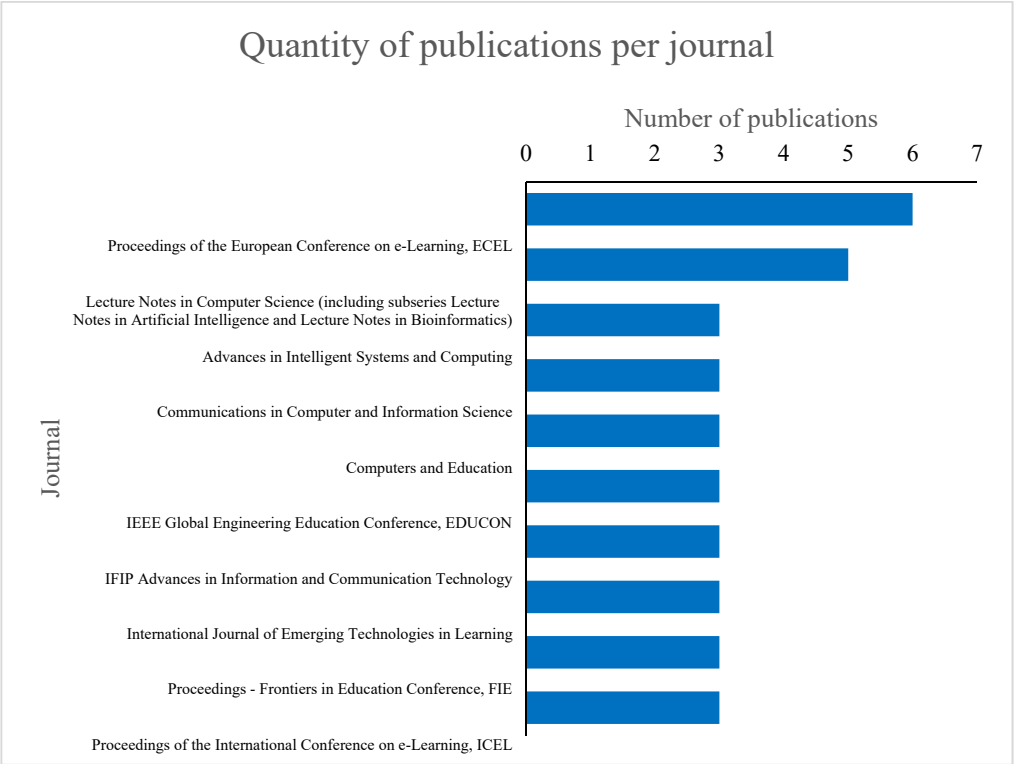


Figure 3. Number of publications per journal. Own elaboration from SCOPUS data.

"Computers and Education" focuses on the impact generated by computing and digital technology in cognition, education and training at all educational levels, and in the open and distance learning environment. In addition, it aims to increase the knowledge and understanding of the topic so that it can become a reference standard (Elsevier 2023a).

With respect to the researchers who carry out studies on virtual tools in teaching-learning processes, Figure 4 provides a list of the 10 authors who have the greatest number of publications on the topic. García-Peñalvo, F.J., with three publications, ranks as the most prolific author on the topic. Francisco José García-Peñalvo is a Professor at the University of Salamanca and belongs to the Department of Computer Science and Automation. His research experience ranges from the study of e-learning, software engineering, and Web 2.0 to technological ecosystems. His publications focus on the processes of technology adoption and the influencing factors.

García-Peñalvo has been recognized as a Distinguished Professor of Escuela de Humanidades y Educación del Tecnológico de Monterrey (School of Humanities and Technology Education) of Monterrey, Mexico. Since 2006, he has been the Director of the GRIAL research group and the Consolidated Research Unit of Junta de Castilla y León (Junta of Castilla and León). In addition, between 2004 and 2009, he served as Vice-Dean of Innovation and New Technologies and Vice-Rector of Technological Innovation of the University of Salamanca. Currently, he is the Coordinator of the Doctoral Program in Training in the Knowledge Society of the same university (Universidad de Salamanca 2023; Scholar 2023).

The other authors on the list are Sánchez-Prieto J.C., Olmos-Migueláñez S., Bekiarski A., Boumiza S. and Souilem D., all with two articles.

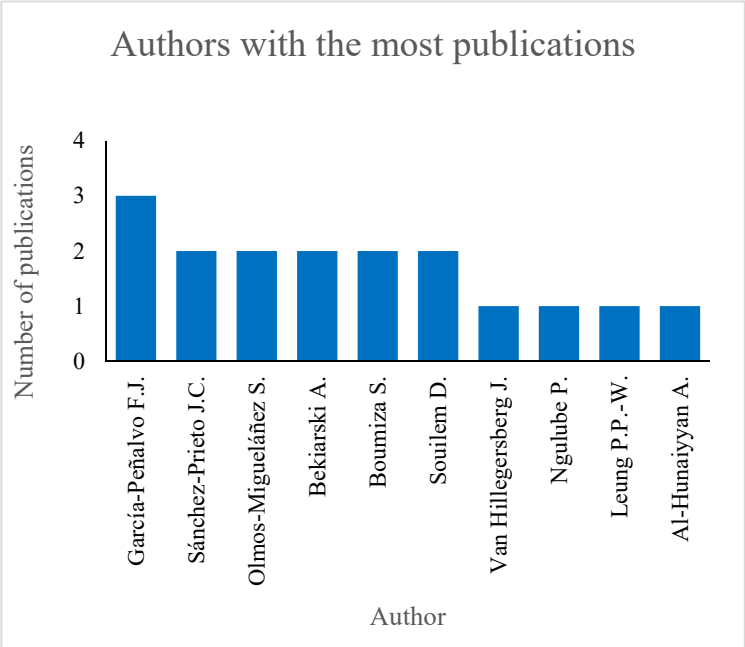


Figure 4. Authors with the greatest number of publications. Own elaboration from SCOPUS data.

4.2. Quality Indicators

This section presents the bibliometric indicators of quality for the use of virtual tools in teaching-learning processes. As mentioned above, quality indicators are directly related to the impact of a publication; that is, with the number of times it has been cited (Durieux and Gevenois 2010; Gómez et al. 1999).

Figure 5 shows the 10 journals with the highest number of citations in the field. Leading the list is the journal "Computers in Human Behaviour", which is dedicated to the study of the use of computers from the psychological point of view; that is, the use of computers in areas related to psychiatry and psychology, as well as the impact that such use has on individuals or society (Elsevier 2023b). An example of this is presented in the article published by (Sánchez-Prieto et al. 2019); the authors indicate that there are external and internal barriers that influence the adoption process of teachers regarding the use of mobile devices in academic environments. The first case refers to the availability of resources in institutions, and the second to teachers' barriers; the results indicated that compatibility and enjoyment have influential roles in the adoption process. Likewise, (Prieto et al. 2015) formulated a complete theoretical model that integrates the constructs considered the most relevant to explain the process of technological adoption by teachers, in which perceived enjoyment, enabling conditions, self-efficacy, device anxiety, subjective norms, perceived usefulness, the perceived ease of use and behavioural intent were defined as influential variables. It also includes a construct that has been little explored in previous studies, i.e., resistance to change.

Additionally, 2.8% of the journals account for 48.7% of the citations on the application of virtual tools in teaching-learning processes.

Regarding the number of citations per author (see Figure 6), different researchers have made valuable contributions to virtual tools in teaching-learning processes and have become leading authors with the highest number of citations in studies related to the topic. Table 1 lists some of the most cited authors with their respective contributions.

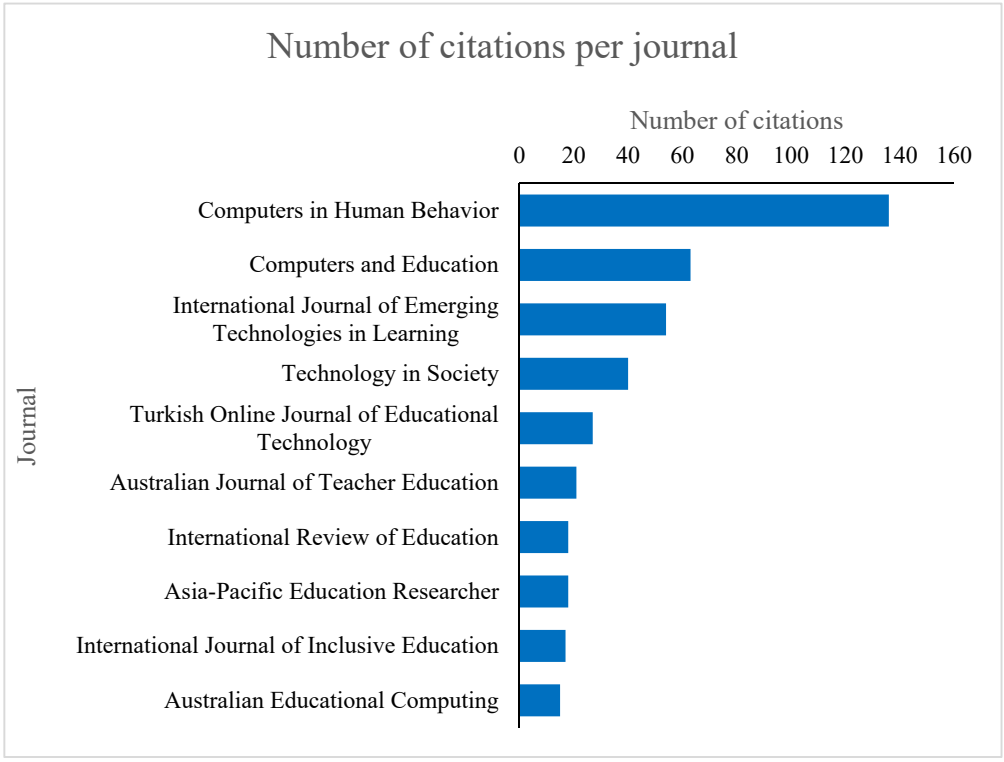


Figure 5. Number of citations per journal. Own elaboration from SCOPUS data.

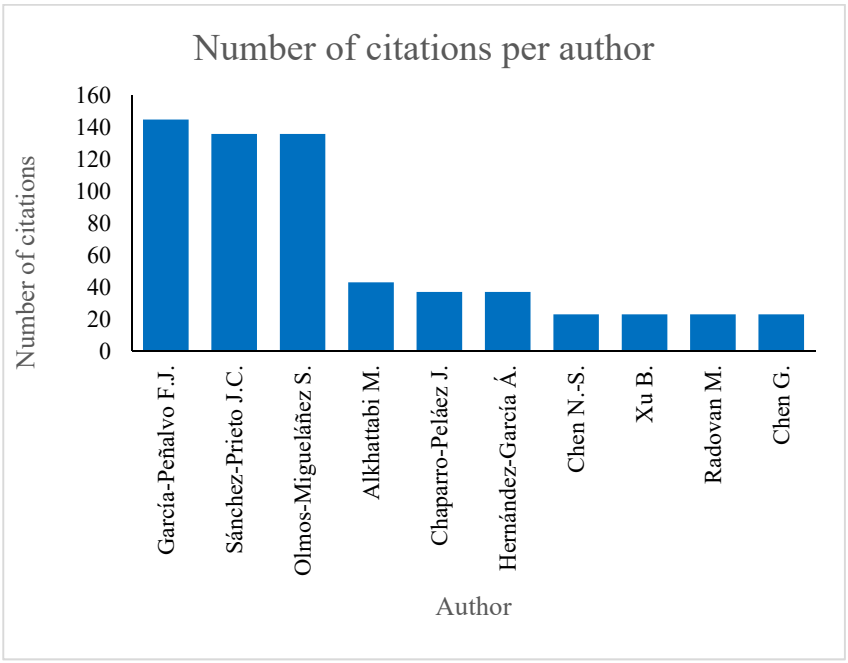


Figure 6. Number of citations per author. Own elaboration from SCOPUS data.

Table 1. Main topics and areas of study of the most cited authors of publications on virtual tools in teaching-learning processes.

Author	Research Area	Topic Covered in the Article	Reference
García-Peñalvo F.J.	E-learning, software engineering, web 2.0 and technological ecosystems	Factors involved in the adoption of mobile technologies in academic environments	(Sánchez-Prieto et al. 2019)
Sánchez-Prieto J.C.	Education, M-learning, technological acceptance		
Olmos-Migueláñez S.	Education		
Alkhattabi M.	E-learning, market intelligence, data mining.	Importance of the application of augmented reality in training	(Alkhattabi 2017)
Chaparro-Peláez J.	Information systems, electronic commerce, E-learning, learning analysis, technological acceptance	Factors involved in the adoption of mobile technologies in academic environments	(Sánchez-Prieto et al. 2019)
Hernández-García A	Information systems, digital transformation, digital marketing, learning analysis, technological acceptance		

Note: Source: Own elaboration.

The most cited authors all address the benefits that virtual tools provide to educational processes. Likewise, they mention the factors involved in the adoption process and the importance of having well-designed systems that contribute to training and serve as a strategic ally for teachers and institutions. Importantly, 3.44% of the authors account for 33.4% of the citations in the field, indicating that their research has contributed significantly to academic environments.

4.3. Indicators of Structure

Structure indicators measure connectivity among publications (Norris and Oppenheim 2007), authors and areas of knowledge, which are constantly associated with the construction and analysis of social networks composed of nodes and links. The nodes are the authors responsible for researching and publishing results, and the links are co-authors (Villa et al. 2018). In this way, by analysing these networks, it is possible to determine outstanding researchers in the field and define the dynamics in which they work (O'cass and Fenech 2003).

Figure 7 shows the relationship among authors who have at least two publications together. Nine collaboration networks were identified among the authors with the greatest number of citations in the use of virtual tools in teaching-learning processes.

In this sense, one of the main nodes of scientific cooperation is between the authors J.V. Carvalho, A. Abreu, A. Rocha and M.P. Cota, who have partnered for the scientific dissemination of the article entitled "*The Electronic Booklet on Teaching-Learning Process: Teacher and parents' vision of students in primary and secondary schools*".

Likewise, another of the main international scientific and academic association networks in the dissemination of articles on the use of virtual tools applied to the teaching-learning process is composed of the authors J.C. Sánchez-Prieto, F.K. García-Peñalvo and S. Olmos-Migueláñez, who are positioned in the top three of the authors who have generated the most knowledge on the subject (see Figure 4), and those who have obtained the greatest impact (see Figure 6), with articles such as "Informal tools in formal contexts: Development of a model to assess the acceptance of mobile technologies among teachers", "Break the walls! Second-order barriers and the acceptance of m-Learning by first-year pre-service teachers" or "Mobile learning adoption from informal into formal: An extended TAM model to measure mobile acceptance among teachers", among other related articles.

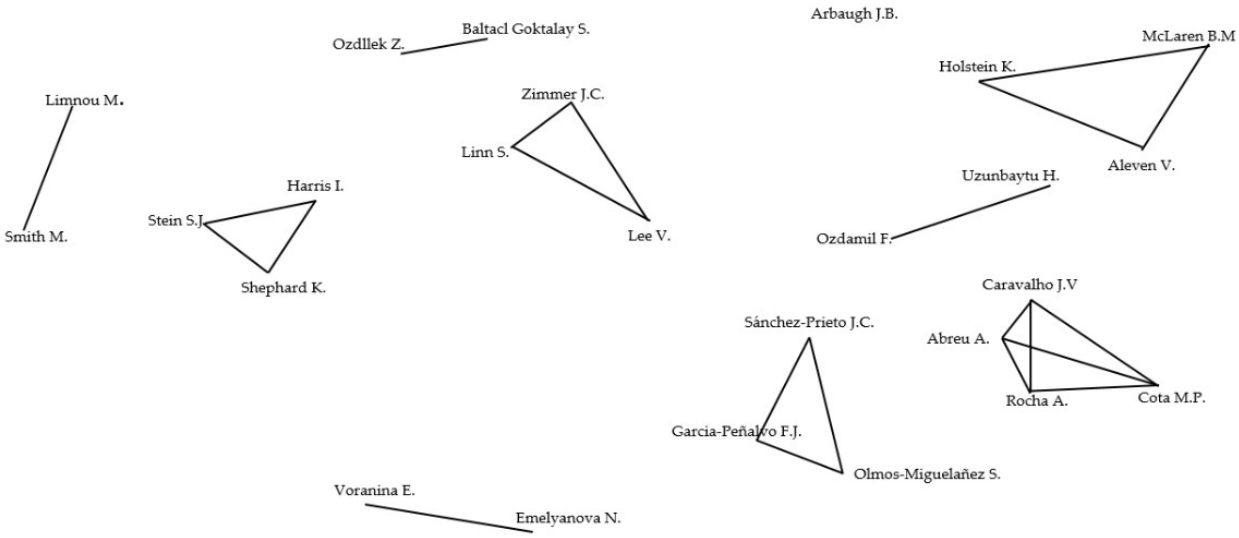


Figure 7. Network of the most cited authors. Own elaboration based on SCOPUS data.

4.4. Trends

With keyword analysis, the topics that generate the greatest number of publications in the field can be identified; that is, those that have greater research trends. Figure 8 shows the most common keywords in the articles published on virtual tools in educational processes.

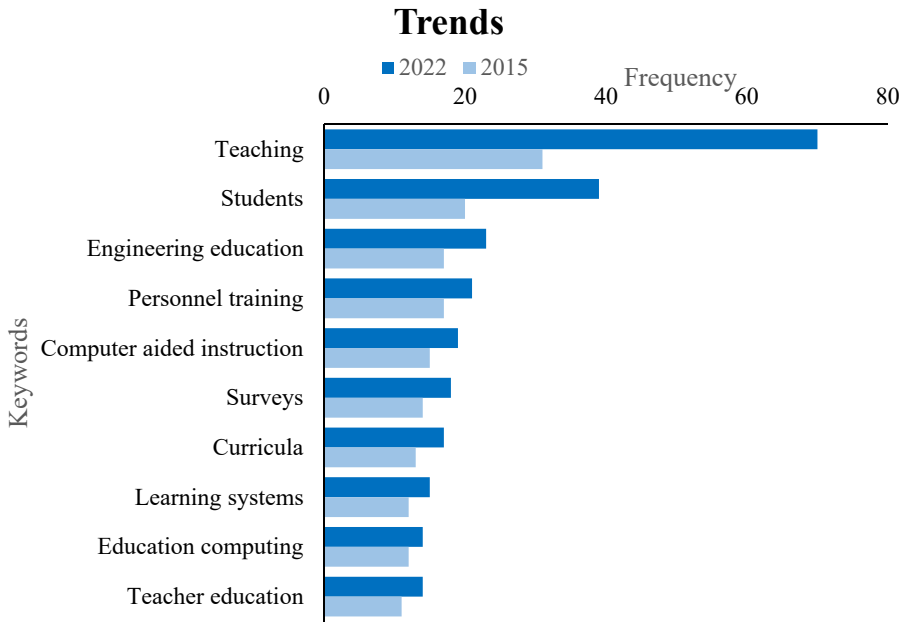


Figure 8. Keywords most used in research on the topic. Own elaboration from SCOPUS data.

Figure 8 compares 2014 and 2019, showing that the most frequently appearing keyword in research on the topic was teaching, with 71 associated publications for 2019, a result that is expected given that this is a fundamental part of the educational process. Second, the keyword students were associated with 39 publications in relation to direct beneficiaries of training as well as essential elements in the introduction of ICTs in training environments (Valencia-Arias et al. 2019). The keyword engineering education ranked third; for example, (Limniou and Smith 2010) expresses the importance of involving virtual training environments in the teaching of specialised areas, such as engineering. In fourth position is personnel training, given that ICTs alone cannot create changes in educational

processes; that is, it is necessary to have trained personnel that efficiently use the tools and contribute to effective implementation and integration into processes, to make the most of their potential, a role that teachers would play (Valencia-Arias et al. 2019).

Studies on virtual tools can be grouped into four general categories, which are presented in Figure 9. First, the researcher García-Peñalvo, F.J., has focused his interest on the study of the factors involved in the process of adopting virtual tools in educational environments (Sánchez-Prieto et al. 2019; Prieto et al. 2015; Sánchez-Prieto et al. 2016; Prieto et al. 2014). Papanikolaou, K., has dedicated herself to studying the design of instruments that contribute to pedagogy and effective content for the teaching of technology through b-learning (Zalavra and Papanikolaou 2018; Makri et al. 2014). Similarly, Baltaci-Goktalay et al. (Ozdilek and Baltaci-Goktalay 2013; Baltaci-Goktalay and Ozdilek 2010) has studied the need to create content that meets the needs and characteristics of students as well as the importance of the content being prepared by subject experts, who provide reliable and valid information. Boumiza et al. (2016, 2017) focuses on the relevance of having distance learning platforms that allow better interaction with students and facilitate tracking the activities in which students engage.

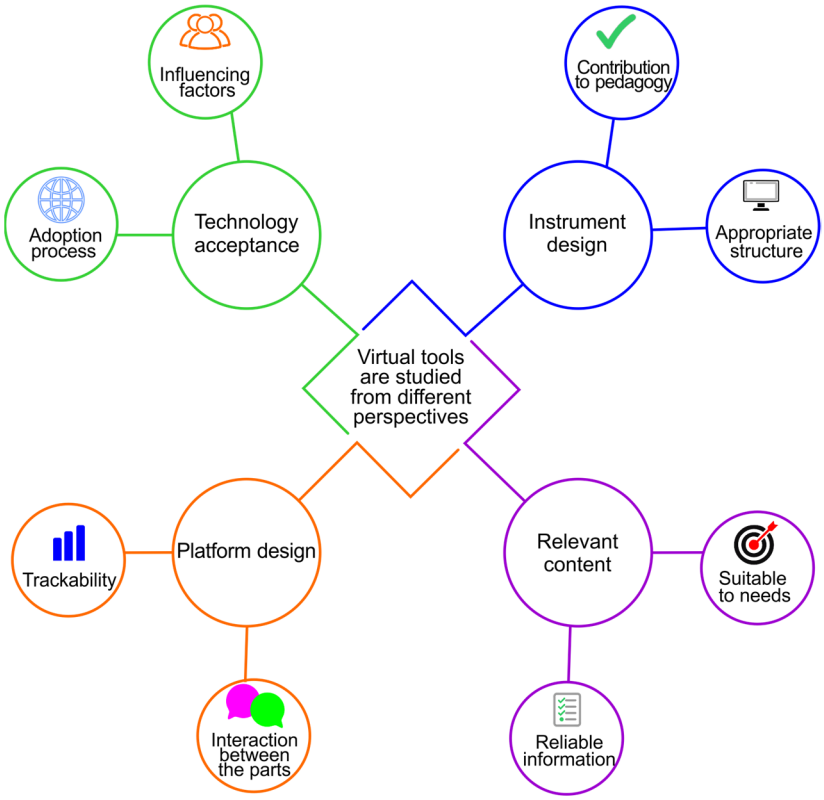


Figure 9. Categories of study for virtual tools. Own elaboration.

5. Discussion

The materialization of a bibliometric analysis includes, as previously evidenced, the analysis of keywords (see Figure 8). In this sense, Figure 10 shows the main network of co-occurrence of keywords in the scientific production on the use of virtual tools in teaching-learning processes based on the association of thematic clusters. Therefore, the main thematic cluster is the green one, with concepts such as Higher Education, Online Education, TAM, Technology Adoption, COVID-19, Distance Learning, Perceptions, and Perceived Usefulness. This cluster relates the use of validated psychometric models, such as the TAM, to understand the factors of the adoption of virtual education technology based on variables such as perceived usefulness, which has been validated mainly for

higher education, whose adoption process was accelerated in the context of the COVID-19 pandemic.

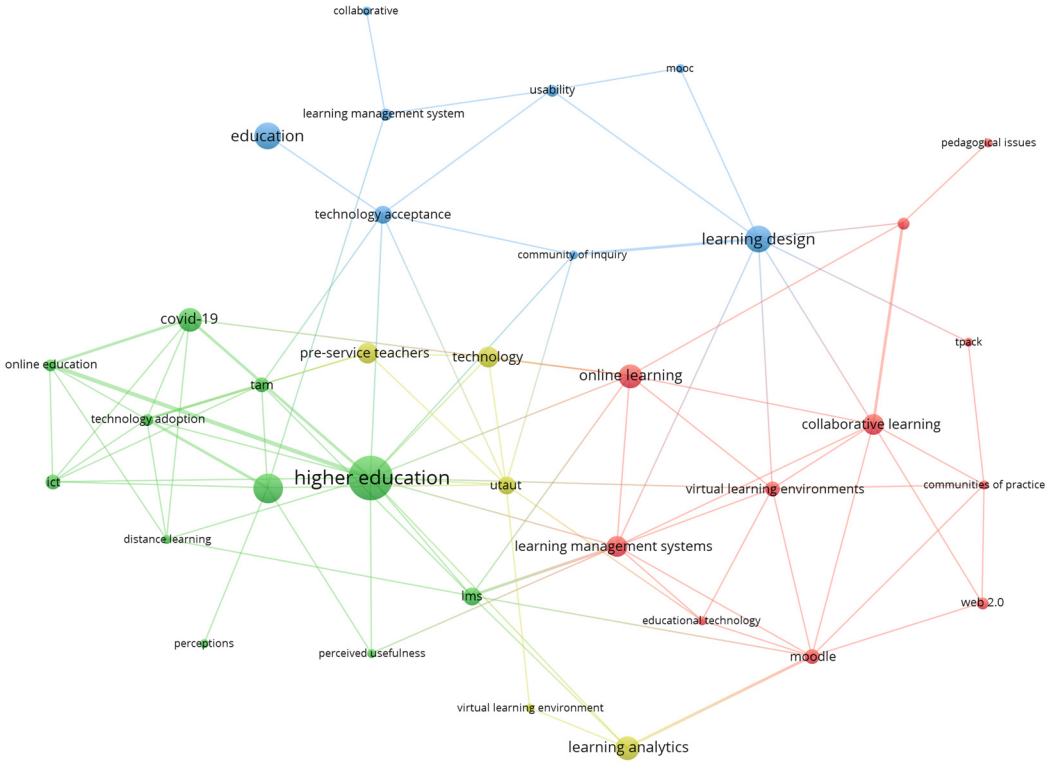


Figure 10. Keyword co-occurrence network. Own elaboration.

Subsequently, the second most relevant thematic cluster is the red one, which accounts for the direct association of keywords such as Online Learning, Learning Management Systems, Technological Education, Moodle, Virtual Learning Environments, Collaborative Learning, and Web 2.0, among others. This cluster shapes one of the main thematic associations in the research field, such as the one that explains the importance of learning management systems for the direction toward increasingly virtual-oriented learning. The above is related to virtual learning environments, where Moodles and Web 2.0 allow more collaborative methodologies between students and teachers.

On the other hand, Figure 11 shows the main topics that should be addressed as a research agenda based on a Cartesian plane, where the X-axis measures the frequency of use of each word. In contrast, the Y-axis evaluates the concept's topicality and validity level. In this sense, there are four quadrants, where the fourth quadrant positions concepts that, being frequent but not very current, are categorized as decreasing. However, in this quadrant, there is no term.

Then, there is quadrant three, where there are terms that are not very prominent, as they are infrequent and current, having keywords such as Web 2.0, Secondary Education, Pedagogical theme, Moodle, Adoption, UTAUT model, and Usability. Concepts that, in the current conditions of the subject, do not appear as preponderant or indispensable for the future development of the subject.

Then, we have quadrant two, with infrequent concepts, but which, being among the most current or valid, are categorized as emerging keywords in the scientific field. In this case, finding important terms such as Virtual Learning Environments, Learning Analytics, Perceived Usefulness, COVID-19 and Online Education is based on the use of virtual tools in teaching and learning processes. These concepts, being positioned as emerging in the scientific literature, still have a significant margin of growth for future research to expand

knowledge about their importance for current education based on the current technological characteristics.

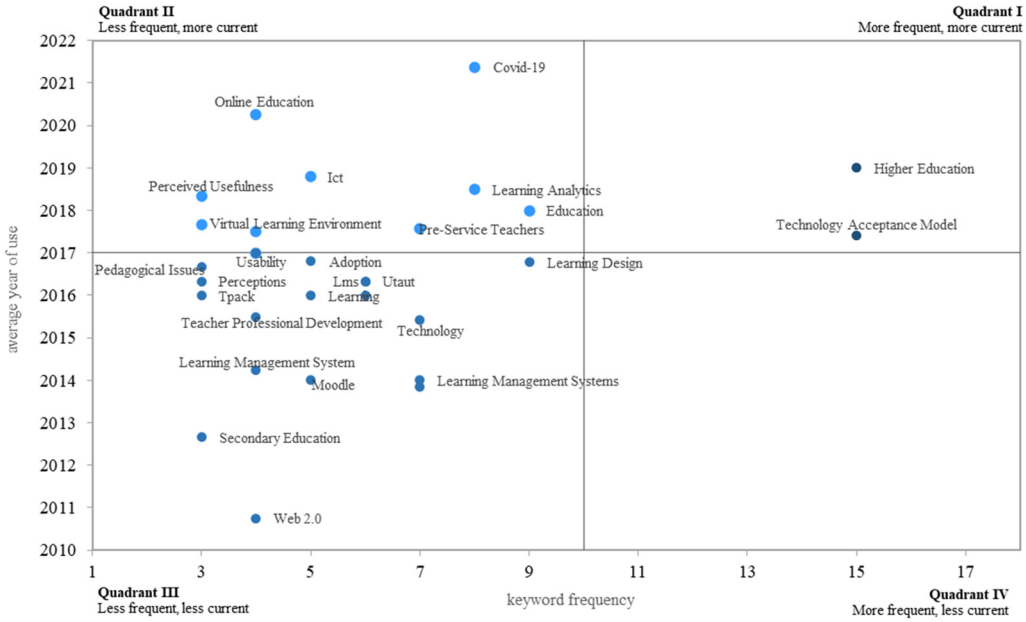


Figure 11. Keyword validity and frequency. Own elaboration.

Additionally, we have quadrant one, where the most important concepts for the scientific literature on the subject are positioned, as they are the most frequent but also the most current, so they are considered growing keywords. In this quadrant, we have, on the one hand, one of the most important and validated psychometric models of today, such as the Technological Acceptance Model, through which, from the analysis of specific variables, it points to the understanding of the acceptance or adoption of virtual learning technologies, which is consistent with other leading concepts such as Higher Education, the context in which these mechanisms or virtual tools for teaching and learning have been validated more rigorously and frequently.

Finally, it is relevant to highlight that although the associated topics have gained strength and have increased the frequency of their appearance in research worldwide, not all countries have an adequate implementation of virtual tools in academic environments, given that there are political, cultural, social and economic differences that hinder the strengthening of the use of these technologies in teaching processes, causing the implementation of new academic strategies to be slow or non-existent (Valencia-Arias et al. 2019). Similarly, if countries and institutions understand the advantages that can be obtained by enhancing the use of virtual tools, they could improve the levels of coverage and accessibility, eliminating the barriers of time and space that limit education (Sánchez-Prieto et al. 2019). Additionally, it would be possible to track the evolution of each student, strengthen knowledge networks, manage information in a more significant way, and design instruments and content that are aligned with the students' needs, among other benefits (Zalavra and Papanikolaou 2018; Ozdilek and Baltaci-Goktalay 2013).

During the bibliometric analysis performed, it was evident that there was a high correlation between the results obtained and those mentioned in other studies on the topic. The research developed by (Comas Gonzalez et al. 2017) explored global trends in education with advanced ICTs, finding that virtual education has a strong connection with immersive environments, understanding these as three-dimensional spaces or places, real or imaginary, created by a computer, with which an individual can interact, producing and generating the feeling of being inside a specific place. This is in addition to being spaces with the capacity to recreate areas of cultural, economic, social and identity recombination that broaden the possibilities of experiences and collaborative learning, favouring the development of

learning communities. In this sense, technology is an enabler of pedagogical innovations rather than an innovation in itself (Komar et al. 2022). Additionally, these immersive environments enable the development of multiple competencies, such as social, cultural and coexistence aspects, when immersed in a collaborative environment (De Fino et al. 2020; Vander Valk 2008).

Similarly, in the study conducted by (Fombona et al. 2017), there is a trend highlighted in educational philosophies, with tools such as m-learning and augmented reality technology, which should be driven from creative and playful challenges, for the teaching-learning process. This motivates changes in methodology as the mechanisms of the modulation of educational interaction, overcoming the mere relocation of space and time. Likewise, (Liu et al. 2022) expresses the importance of the use of augmented reality in teaching sports because it allows greater interaction and student learning for practical courses. Additionally, (Cano et al. 2016) considers that the general process of technological implementation should not be considered systematically, but instead should be approached from a perspective adapted to a specific topic. This is why the trend can be considered a true image of the level of penetration that m-learning and augmented reality technology has had in teaching-learning processes.

Another bibliometric study conducted by (Martin et al. 2011) states that the trend in teaching-learning processes is based on the use of virtual tools, such as social networks, content created through the collaboration of interconnected groups, gamification, and virtual worlds or spaces, through augmented and immersive reality, as well as mobile devices. In accordance with the above, in the field of training in specific areas such as medicine, there is a strong increasing trend in virtual laboratories for teaching because these virtual and remote spaces reduce the cost associated with conventional practical laboratories because of their required equipment, space and maintenance staff. In addition, virtual laboratories provide additional benefits, such as support for distance education, improved accessibility to laboratories for disabled people and more safety for risky experimentation (Biddau et al. 2022; Akgül and Uymaz 2022).

Given the speed of change in the indicators and statistical data of bibliometrics, even more so with the scientific content of ICT, which changes at every moment, there are limitations in the indicators that allow measuring the forms and actions of ICT tools in the use of strategies in teaching and learning environments. However, there are merits to mitigate this limitation, since the use of the PRISMA methodology with the inclusion and exclusion criteria, limiting the searches by specific time frame, will also give updated results in line with current and future research related to ICT tools for teaching and learning.

6. Conclusions

When conducting research on a particular area, it is important to know the level of studies related to the topic of interest to determine the relevance and contribution that the results may have on the target audience. For this, bibliometric analyses are used, through which the contributions that different authors have made to the area are analysed to allow the audience to become familiar with journals, publications, authors, and representative countries and authors who have had a greater impact in the field. This serves as a basis for the development of new studies, becoming a reliable source of information through which useful patterns are identified for the advancement of research and scientific development.

The results of this analysis indicated that the implementation of virtual tools in the teaching-learning processes provides institutions, at all educational levels, flexibility and broadens coverage and accessibility to training, generating changes in the classic institutional structures, changing their way of operating. This allows people who could not access educational systems to study from the places and at the time they want, breaking down barriers that in previous years were immovable. In addition, through new teaching methodologies, students heighten their interest and motivation to engage in learning activities, creating interaction networks with other students and with teachers.

It is important to determine the factors that intervene in the process of technological adoption, both for teachers and students, to identify the issues that institutions must address to adequately align themselves to the needs of today's world. Creating appropriate platforms with relevant content will ensure that information reaches students correctly, strengthening their motivation to participate in the activities that training environments offer. In addition, platforms must have systems that facilitate trackability by institutions so that continuous improvement plans can be designed that contribute to the correct implementation of virtual systems.

Therefore, having well-designed systems that provide adequate training and are widely adopted will help institutions offer their specialised training services to different people around the world. Given that the application of virtuality has expanded participation not only in general areas of knowledge but also in specific areas, any activities involving risk or high infrastructure costs for institutions can be replaced by virtual environments that enable the realization of those practical activities that are essential for the academic training of students.

Finally, creating collaboration networks allows researchers to work with other people interested in the topic, obtaining different points of view that provide a greater number of contributions from different perspectives, and thus achieving a more global vision of the application of virtual tools in teaching-learning processes.

In future work, the authors propose to study the performance and adoption of virtual tools by educational institutions in the post-pandemic and economic reactivation era. Likewise, we aim to review how the implementation of virtual tools has progressed in the teaching of specific areas, as is the case of the application of virtual reality.

Author Contributions: Conceptualization, V.B.-G., A.R.D. and A.V.-A.; methodology, V.B.-G., L.G.R.-H.; and A.V.-A.; software, L.G.R.-H. and V.B.-G.; validation, J.C.V.G.; formal analysis, L.G.R.-H. and A.V.-A.; investigation, V.B.-G., L.G.R.-H. and A.V.-A.; resources, V.B.-G., A.R.D. and J.C.V.G.; data curation, V.B.-G., A.R.D. and A.V.-A.; writing—original draft preparation, V.B.-G. and A.V.-A.; writing—review and editing, V.B.-G. and A.V.-A.; visualization, L.G.R.-H. and A.V.-A.; project administration, V.B.-G.; funding acquisition, A.V.-A. and J.C.V.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Instituto Tecnológico Metropolitano (Grant Number—P21102) and The APC was funded by Universidad Señor de Sipán—USS.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

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