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LONG PAPER

A bibliometric analysis and visualization of e-learning adoption using VOSviewer

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Abstract
Even though being perceived as a novel approach, multiple authors claim that the digital transition of all sectors in society started when information and communication technologies (ICT) started to be an integral part of our daily lives. The education sector currently represents one of the contexts where the use of ICT is more promising and allows to reach greater benefits, mostly due to the wide range of tools, applications, and management and methodological approaches that are associated with e-learning. With the above in mind, a bibliometric analysis of the e-learning adoption topic has been performed, aiming on delivering a detailed analysis of the status of the topic. This analysis was carried out by analyzing the scientific literature indexed in the Scopus database that addressed the multiple stages of the e-learning adoption process (i.e., acceptance, adoption, and use). Our study analyzed 896 documents published between 1989 and 2021, of which 98.3% represented papers published in journals and conference proceedings.

Keywords e-Learning · e-Learning acceptance · e-Learning adoption · e-Learning use · Bibliometric analysis · VOSviewer

1 Introduction

As digital transition began to encompass educational institutions, from basic education schools to universities and polytechnique institutes, it was possible to perceive the establishment of strategic approaches that not only focused on the adoption of innovative technologies, but also on the adoption of innovative educational and management strategies that are perceived as compliant with the continuously emerging challenges in the "education world" [33]. By merging these innovative technologies, such as ICT—information and communication technologies, a plethora of opportunities has emerged for students, who were given a new set of knowledge repositories and approaches to improve their learning process, and for teachers, that could improve the efficiency and overall efficacy of the teaching methods and initiatives they were applying and trying to develop [15].

Despite the increasing adoption of ICT for educational purposes and the prominent role that the "internet" has had in this phenomenon, there is still a set of issues concerning not only this adoption process but also the actual use of these technologies [46]. As argued by authors such as Hamid [16] and Aparicio et al. [3], when focusing on e-learning (the concept typically applied to characterize the use of ICT for educational purposes), one should address all elements that encompass it, namely the pedagogical dimension, the content strategy, the user interface (UI), and also the inherent information architecture.

According to existing literature [19, 25, 27, 43], these issues have been the focus of attention by both researchers and practitioners during the past decade, but there are still multiple perspectives that have not been addressed and that are considered to have a serious impact to the full adoption and use of e-learning.

Thus, with the abovementioned in mind and considering the need to concentrate, in a focused manner, on the multiple perspectives present in the existing literature on the topic of

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e-learning adoption and use, and consequently stimulate further developments of this knowledge and the arise of innovative approaches and perspectives, a decision was made to undergo a wide-range exploration and bibliometric analysis to the existing literature on the topic. After acknowledging the large volume of scientific data associated with the terms and concepts we were aiming, and considering Donthi et al. [11] and Sandnes [41] arguments, the research team opted to perform a bibliometric analysis of the referred data and have chosen VOSviewer as the tool that would support this task [7].

The remainder of the paper is structured as follows. The paper begins by presenting the methodological approach that supported all the performed identification and analysis of existing literature, followed by an in-depth overview of the achieved results. Next, the referred results are discussed according to the perspectives of other authors on the topic. The paper concludes with its final remarks and a brief highlight of the detected limitations and research topics that should be focused on the future.

2 Methodology (data and methods)

2.1 Sources of information

Drawing on the arguments by Sweileh [44] and Yas et al. [53], the scientific data used as the basis for this study were selected from the Elsevier Scopus database. This database, created in 2004 by Elsevier, currently holds more than 77.8 million records (post-1969) from which over 23,000 are peer-reviewed journals, 294 trade publications, over 852 book series, and over 120,000 worldwide scientific events [13]. Hence, it is possible to perceive that Scopus represents one of the most comprehensive views of the current state of research at a global level. According to Agarwal et al. [1], besides the global context of Scopus, it also permits its users to benefit from a series of features that accelerate bibliometric analysis, such as multicriteria filters that allow for segmentation of the global sample (for example, journal name, type of document, year of publication, authors' names, authors' affiliations, number of citations, etc.).

2.2 Study design

As one can perceive by analyzing the existing studies on the technology adoption topic (acceptance, adoption, and use), the most relevant contributions that have arisen are the theoretical models that not only identify the determinants of the adoption of a given technology but also characterize the hypothetical relations between them [20, 35, 40]. As argued by authors such as Taherdoost [45], the most relevant technology adoption theories and models are: (a) theory of reasoned action, (b) theory of planned behavior; (c) theory of interpersonal behavior; (d) technology acceptance model—TAM; (e) extension of TAM; (f) Igbaria's model; (g) social cognitive theory; (h) diffusion of innovation theory; (i) perceived characteristics of innovating theory; (j) motivational model; (k) uses and gratification theory; (l) the model of personal computers utilization; (m) unified theory of acceptance and use of technology—UTAUT; and (n) compatibility UTAUT.

Considering "e-learning" as the use of ICT for educational purposes, it has been perceived by different authors as a technology on its own. Hence, drawing on the above-mentioned, it is possible to infer that the understanding of the e-learning adoption process might be achieved by analyzing the literature that focused not only on the concept of e-learning but also on the most popular technology adoption models and theories. To identify the set of literature records that compose our study sample, we combined the technology adoption theories and models highlighted by Taherdoost [45] with the term "e-learning."

To ensure that the used sample was of the utmost scientific relevance and validity, the "type of document" has been also used as a filter criterion applied to Scopus search tools. Considering this, our study only focused on journal articles, conference papers, reviews, and book chapters (Table 1).

Although the study sample was defined during the final trimester of 2021, and despite the existence of some studies on the e-learning adoption topic in pre-publication for 2022, a decision has been made to define the top limit of publication date to 2021.

Considering all the imposed criteria to the definition of the study sample, in its final state it was composed of 896 documents, where the majority were conference papers (476) and journal articles (405).

3 Results

This section holds a detailed presentation of the performed bibliometric analysis outcomes. The results' presentation starts by characterizing the status of e-learning adoption (3.1) and is followed by the keywords analysis of research hot spots on e-learning adoption. The analysis of the

Table 1 Type of retrieved documents

Type of document	Frequency	Proportion (%)
Conference paper	476	53.1
Article	405	45.2
Review	11	1.2
Book chapter	4	0.4
Total	896	100.0

co-authorships and the co-citation are presented in the final two subsections, respectively.

Considered by existing literature as a statistical method through which one can perform quantitative analysis on voluminous sets of scientific data (i.e., research papers), bibliometric analysis aims at delivering insights into the key areas of research surrounding a given concept and predict future research topics [55]. As argued by Van Eck and Waltman [48], despite the consensual value of bibliometric analysis, a significant part of its value is undoubtedly related to the visual perception one can make of the achieved results. For this reason, VOSviewer has been chosen as the software tool that supported this study.

As explained by Meng et al. [26], VOSviewer is a software tool originally developed in 2010 by Nees Jan van Eck and Ludo Waltman at Leiden University's Centre for Science and Technology Studies (CWTS), which allows for the creation of maps based on network data and for the visualization and exploration of those maps. In fact, VOSviewer can extrapolate and create networks of scientific publications and journals, researchers and research organizations, countries, keywords, and/or terms. The items in these networks can be related by co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation links. According to Van Eck and Waltman [48], the added value of this tool is not only its ability to create the abovementioned networks, but also its ability to collect data from multiple scientific databases, such as web of science, Scopus, dimensions, and PubMed files, and reference managers files, such as RIS, EndNote and RefWorks files.

3.1 Current status of e-learning adoption

3.1.1 Annual trends in publications

From the analysis of the annual trends of publication (Fig. 1), one can perceive that 2003 was the year in which the first paper on the "e-learning adoption" topic was published in Scopus, and from then on to 2017 the growth rate has been constant but not significant. An example of this is the fact that during the 7 years between 2010 and 2017, the number of e-learning adoption papers that were published in Scopus was averaging the high forties/lower fifties. After 2018, the referred research topic has been targeted by a significant number of researchers and this has translated into exponential growth in the number of papers published in the Scopus database, to the point of reaching almost 140 in 2021.

According to Palvia et al. [38], 2017 was the year in which governments, companies, students, and teachers started to converge on the potential opportunities associated with e-learning. This aggregation of perceptions was the result of a series of education and technical training-related challenges that have arisen as a consequence of the global digital transition movement [8], 47. Also, the 2017–2019 period has been the period in which disruptive technologies such as virtual and augmented reality have witnessed the most significant developments and have started to be perceived as potential (optimal) technologies to use as the basis for novel learning and training initiatives [14], 54.

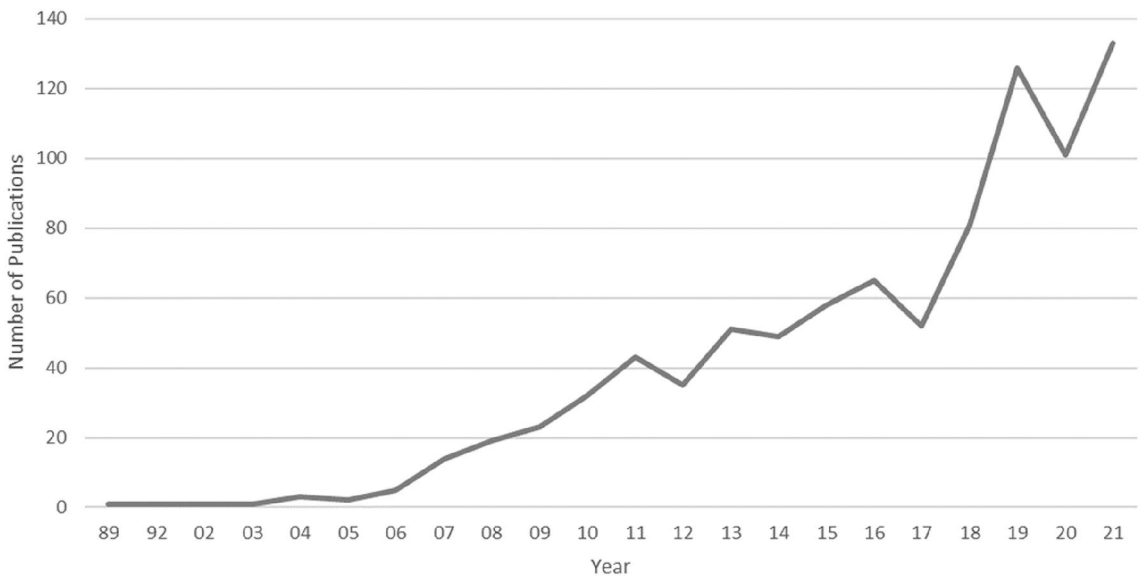

Fig. 1 Annual trends of publications

3.1.2 Distribution of organizations

By analyzing the authors' affiliations, it is possible to observe that the top 10 organizations whose affiliates published on the e-learning adoption topic hold a total of 95 papers (Fig. 2), thus ensuring 10.6% of the total papers on the referred topic. The Universiti Kebangsaan from Malaysia has the greatest number of publications with a total of 14 papers, representing 1.78% of the used scientific data sample. Indeed, Malaysia is the country of origin of 5 of the top 10 organizations with the biggest number of publications, with an aggregate of 50 papers (5.58% of the study sample), followed by Indonesia (20 papers), Hong Kong (9 papers), and Saudi Arabia (8 papers).

Muaadh Mukred and Zawiyah Yusof have been the authors from the Universiti Kebangsaan Malaysia with the biggest number of publications, and they collaborated on 5 papers, 3 of them published in peer-reviewed journals [28, 28, 29, 29–31, 31] and 2 of them in conference proceedings [31]. In the referred publications, the authors have focused on the managerial challenges that are posed to education organizations when implementing a combined approach of traditional learning and e-learning and the opportunities that might arise from transposing their data to an electronic record management system (ERMS). Despite having been published in the last 3 years, these publications have recorded 49 citations in Scopus and 82 in Google Scholar.

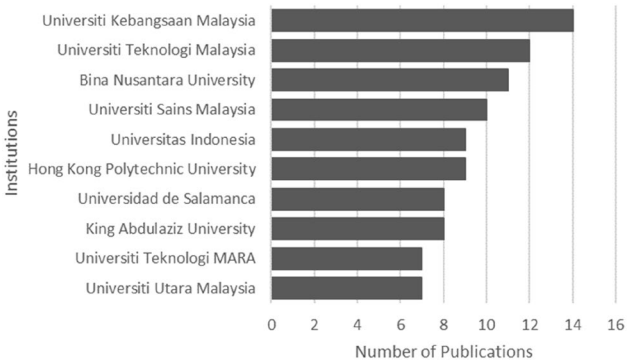

Fig. 2 Top 10 institutes according to the number of publications

3.1.3 Distribution of published journals

From the initial 896 publications that composed the study sample, 41% of the global sample (405) are papers published in 146 peer-reviewed journals. At the same time, 146 of these articles were published in the top 10 journals, "Computers in Education" being the journal with the most articles published, with a total of 27 articles (2.74% of the global sample). Nevertheless, 6 of the referred top journals have published more than 10 papers each. Furthermore, six of the top 10 journal are first quartile, two are second quartile, and the other two are third quartile (Fig. 3).

3.1.4 Distribution of published conference papers

By observing the study sample, it is easily perceived that the majority (476) of the inherent publications refer to papers published in conference proceedings. It is also observable that 150 of the conference papers (31.5%) are published in the top 10 conference proceedings (Fig. 4). Lecture Notes in Computer Science, the Proceedings of the International Conference on e-Learning, and the ACM International Conference Proceedings Series are the most relevant proceedings to focus on the e-learning acceptance, adoption, and use topic, by ensuring almost 10% of the overall amount of conference papers.

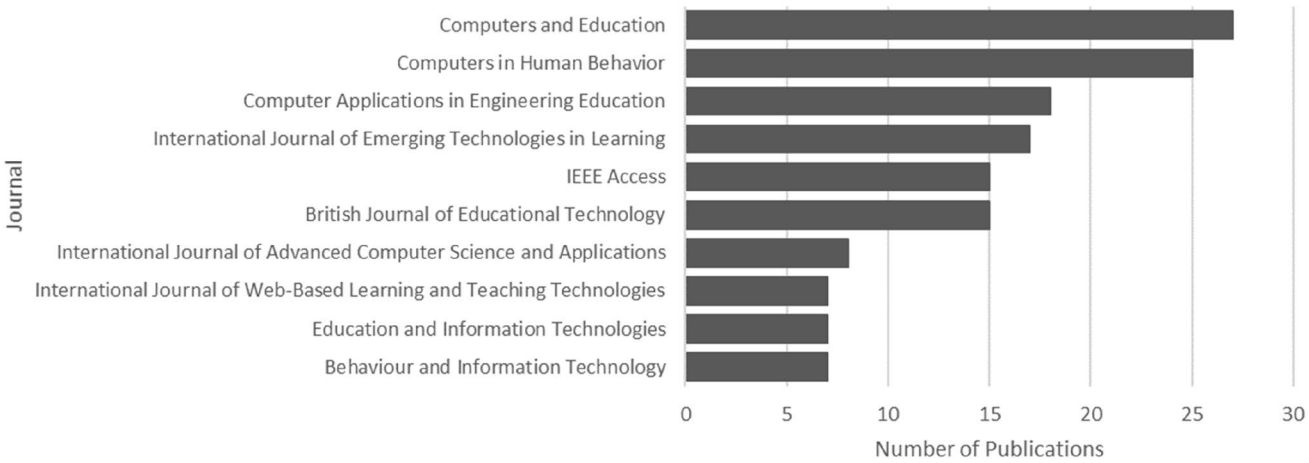

Fig. 3 Top 10 journals according to the number of publications

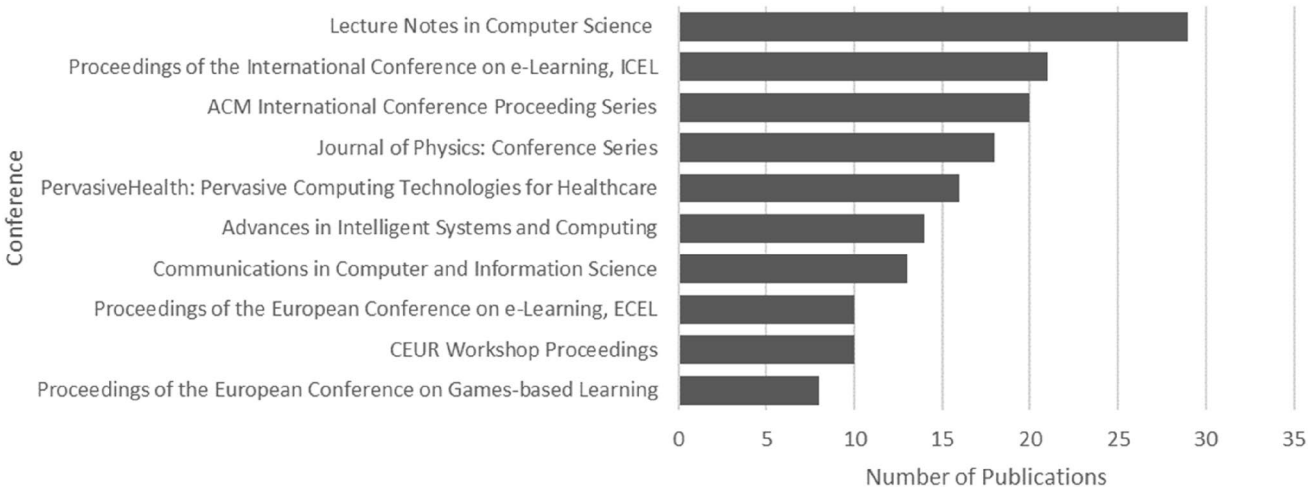

Fig. 4 Top 10 conferences according to the number of publications

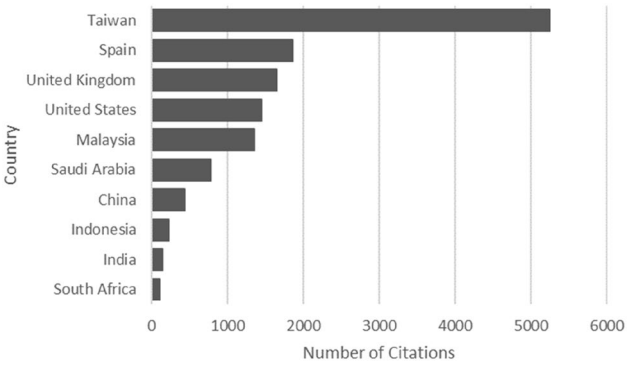

Fig. 5 Top 10 countries according to the number of citations

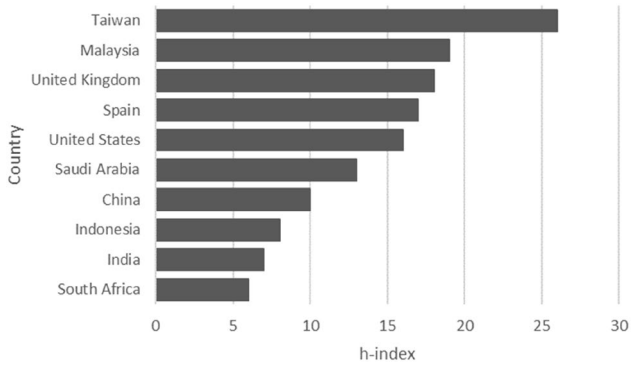

Fig. 6 Top 10 countries according to the H-index

3.1.5 Citation and H-index analysis

As argued by Bai et al. [5], the number of citations of a given paper tends to not only ensure the overall value of its (scientific and/or practical) contribution, but also to impact other aspects more related to the research team, such as funding allocations and even hypothetical rewards. From the analysis of Scopus data on e-learning acceptance, adoption, and use, all the inherent publications reached an aggregate of 18,281 citations. Drawing on the data presented in Fig. 5, the number of citations in the top 10 of the countries that most cited these articles was 13,245 citations (72% of the total number of citations), with Taiwan (5253), Spain (1862), and the UK (1650) being the countries that most cited these same publications.

As perceived by the existing literature, H-index is the term used to describe the relationship between the most H papers that were cited, at least, H times, conceptually demonstrating the impact a given author has on his peers [6]. When Hirsch [17] proposed to use the H-index to evaluate the scientific relevance of each researcher, there were multiple arguments against it. However, to this day, H-index is considered a reliable measurement of the researcher's work and has been adopted worldwide by both education organizations and governing and funding institutions [4].

Taiwan holds the number 1 ranking in terms of H-index (26), followed by Malaysia (19), the UK (18), Spain (17), and the USA, which ranks fifth with an H-index of 16 (Fig. 6). However, when considering the countries with the utmost number of publications on the e-learning acceptance, adoption and use topic, Malaysia ranks first, closely followed by Taiwan. China, which has an H-index of 10, published more than 60 papers and ranks third in the top 10 countries with the biggest publication number (please refer to Fig. 7 for more details), thus allowing us to perceive the possibility that despite producing a considerable volume of publications, China might need to improve their overall quality to the scientific community perceive them as

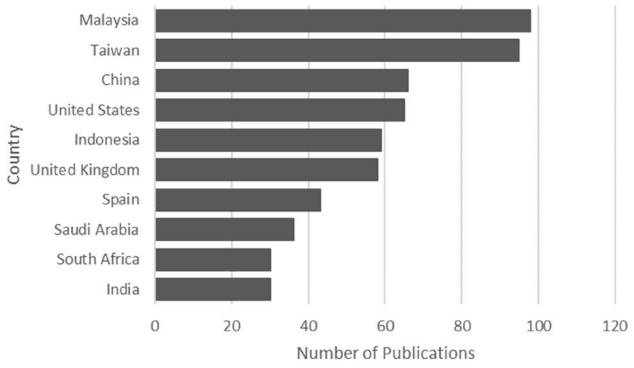

Fig. 7 Top 10 countries according to the number of publications

valuable contributes to the development of the abovementioned research topic.

3.2 Keywords analysis of research hotspots

After a careful analysis of the context of each record of the study sample, we moved forward and started assessing the content of each of the selected publications, and we did so by analyzing their keywords. Through the analysis of the co-occurrence of keywords, we assess the critical points of research in the scientific investigation of e-learning acceptance, adoption, and use. In the 896 publications that composed the study sample, 4420 keywords are used, of which 3191 are used only once. For VOSviewer to deliver a keywords co-occurrence network capable of being visually analyzed and perceptible, the minimum number of occurrences of a keyword used was adjusted to 10 in VOSviewer, thus thresholding keywords with less than 10 occurrences [55].

The analysis of the keywords co-occurrence network (Fig. 8), in which the keywords are labeled with colored circles and their size is correlated with the appearance of the words in the titles and abstracts of the publications (i.e., the greater the occurrence of the keyword, the greater the size of the text and circle) [48], allows to perceive that the keywords with the biggest frequency are: (a) "e-learning" (896); (b) "students" (355); (c) "technology acceptance model" (305); (d) "learning systems" (252); (e) "education computing" (235); (f) "engineering education" (186); (g) "education" (172); (h) "teaching" (148); (i) "surveys" (135); (j) "TAM" (130); (k) "computer aided instruction" (122); (l) "perceived usefulness" (121); and (m) "perceived ease of use" (112). Furthermore, it was also possible to identify 7 keyword clusters.

The distance between the nodes represents the strength of the two-node relationship (i.e., a smaller distance reveals a greater strength). The two words' correlation is represented by the lines, the greater the thickness of the line, the greater the co-occurrence they have [48]. The nodes with link strength greater than 100 are: (a) "e-learning" with "students" (355); (b) "e-learning" with "technology acceptance model" (305),«; (c) "e-learning" with "learning systems" (252); (d) "e-learning" with "education computing" (235); (e) "e-learning" with "engineering education" (186); (f) "education computing" with "students" (185); (g) "e-learning" with "education" (172); (h) "e-learning" with "teaching" (148); (i) "technology acceptance model" with "students" (143); (j) "e-learning" with "surveys" (135); (k) "learning systems" with "students" (133); (l) "e-learning" with "TAM" (130); (m) "computer aided instruction" with "e-learning" (122); (n) "e-learning" with "perceived usefulness" (121); (o) "e-learning" with "perceived ease of use" (112); and (p) "technology acceptance model" with "education computing" (102). A deeper assessment of these relations might be considered as a demonstration that, although practitioners may perceive e-learning as an acquired reality, the truth is that researchers are still more concerned with the acceptance of the technology itself and with the existence of behavioral intentions toward its use, rather than with its actual application and incorporation in all moments of the educational process.

3.3 Co-authorship analysis on e-learning adoption

The execution of a research project is a complex task that in order to produce solid and accurate outputs, tends to involve multidisciplinary collaborations between various researchers [18]. Drawing on Liao et al. [22], analyzing the co-authorship networks is a very focused manner to assess the novelty level of a given research topic, for the establishment of a straightforward analysis of the co-authors' countries of origin, but also the organizations to which the co-authors are affiliated.

3.3.1 Country co-authorship analysis

The country co-authorship analysis demands analyzing which countries have the greatest influence in the field of investigation, as well as the degree of communication between them. The country co-authorship network on e-Learning Adoption models related publications is shown in Fig. 9. The countries with the greatest influence are represented by the size of the nodes. The links, on the other hand, show the cooperative relationship between institutions in the various countries, and their thickness and distance between nodes show the cooperation that exists between countries. The diversification of research directions can be seen by the variety in the number of colors on the map. The countries with the highest number of publications are Malaysia (98) and Taiwan (95), the countries with the uppermost number of citations are Taiwan (5253) and Spain (1862), and the countries with the highest total link strength value are

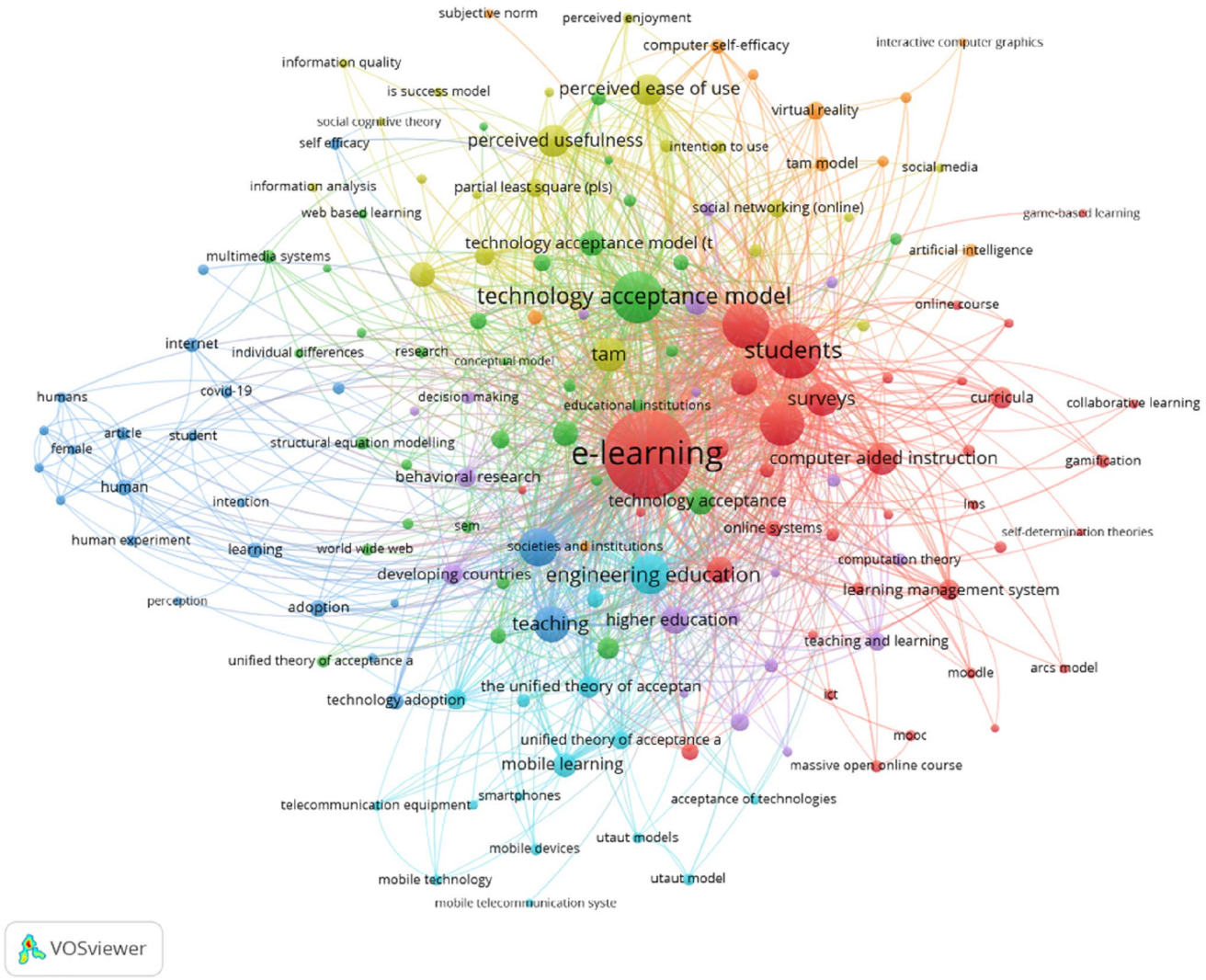

Fig. 8 The keywords co-occurrence network of e-learning adoption models-related publications

the UK (40) and Malaysia (42). The strongest link strength relationships are between the UK and Saudi Arabia, and Malaysia and Saudi Arabia both with 6.

3.3.2 Highly cited publications

The scientific community holds a perception that the number of citations of a given paper is directly related to its overall quality, and hence the more the citations, the higher the paper quality. To assess the potential impact that the papers on e-learning acceptance, adoption, and use, which composed our study sample, might have on the development of science, we analyzed the 10 papers with the biggest number of citations. Table 2 displays the title, journal, authors, year, and citation of the most-cited papers. The average number of citations per article is 2.4. The top 10 most-cited papers were published between 2004 and 2010, which might indicate that these are considered the theoretical foundations on the topic. Despite the number of publications on the referred topic having significantly raised after 2011, up to this point there is no reflection of this growth on the overall number of citations. "Computers and Education," "British Journal of Educational Technology," "Computers in Human Behavior," and "Information and Management" are the journals whose papers hold the most citations.

In his research, Lee [21] aimed to study the determinants of e-learning continuous use by combining three different theoretical models, namely the expectation–confirmation theory, the technology acceptance model, and the theory of planned behavior. The author proposed a novel research model, validated using a sample of over 360 learners, that argued that satisfaction is a very strong determinant of the existence of behavioral intention to continue using e-learning. At the same time, the author was also able to highlight

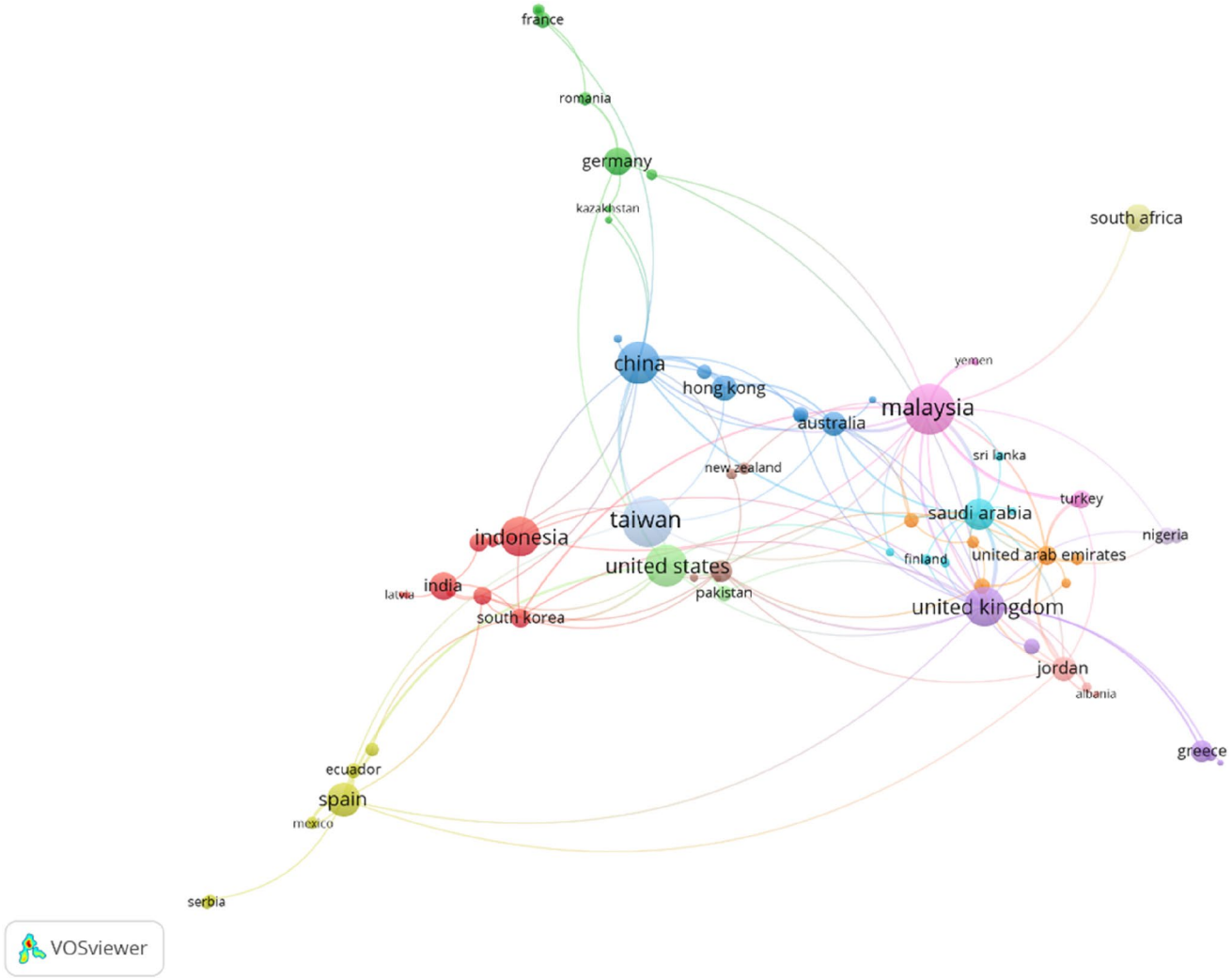

Fig. 9 The country co-authorship network of e-learning adoption models-related publications

that students' satisfaction is significantly dependent on their perception of the usefulness of e-learning and the tools that support it. This paper holds the highest citation ranking, with 667 citations.

Drawing on the evolution of mobile technologies and the extreme increase in their global adoption, Wang et al. [52] focused on the application of these technologies in the education context. The use of mobile technologies for education is conceptually perceived as m-learning, and its overall acceptance and use, in 2009, was still something that required further study. By supporting their research hypothesis on an extended version of the unified theory of acceptance and use of technology (that added perceived playfulness and self-management of learning as extra determinants), and on the impact that gender and age might have on the model's ability to accurately characterize the acceptance and use of m-learning, the authors performed an empirical study involving 330 respondents in Taiwan. The study concluded that performance expectancy and perceived playfulness are triggers to the rise of behavioral intentions toward using m-learning that as learners become older they tend to value more the effort expectancy, social influence has a part in the rise of behavioral intention (particularly for older men) and that despite being considered significant in what concerns its impact on behavioral intention to use m-learning, self-management of learning is considered to be more relevant to women. With over 630 citations, this paper ranks second in the top 10 ranking of most-cited papers on the e-learning acceptance, adoption, and use topic.

3.4 Co-citation analysis

According to Liao et al. [22], when in a given citing item references list two items (e.g., articles, journals, authors) are cited at the same, we are in the presence of a co-citation relationship, which can be used—as argued by Donthu et al.

Table 2 Top 10 papers citations

Title	Journal	Authors	Year	Citation
Explaining and predicting users' continuance intention toward e-learning: an extension of the expectation-confirmation model	Computers and Education	[21]	2010	667
Investigating the determinants and age and gender differences in the acceptance of mobile learning	British Journal of Educational Technology	[52]	2009	633
Investigating students' perceived satisfaction, behavioral intention, and effectiveness of e-learning: a case study of the blackboard system	Computers and Education	[23]	2008	590
The acceptance and use of a virtual learning environment in China	Computers and Education	[49]	2008	520
Empirical examination of the adoption of WebCT using TAM	Computers and Education	[34]	2007	474
Gender differences in perceptions and relationships among dominants of e-learning acceptance	Computers in Human Behavior	[36]	2006	444
Factors affecting engineers' acceptance of asynchronous e-learning systems in high-tech companies	Information and Management	[37]	2004	411
Understanding e-learning continuance intention in the workplace: a self-determination theory perspective	Computers in Human Behavior	[39]	2008	401
Extending the TAM model to explore the factors that affect intention to use an online learning community	Computers and Education	[24]	2010	394
Learning presence: toward a theory of self-efficacy, self-regulation, and the development of a communities of inquiry in online and blended learning environments	Computers and Education	[42]	2010	349

[12]—to examine the relationship and structure of research topics. With this in mind, in our research, a focused co-citations analysis has been performed to highlight the possible relations that exist between authors, articles, and journals on the e-learning adoption topic.

3.4.1 Reference co-citation analysis

Transposing the abovementioned to the specific context of research papers, when a given paper simultaneously cites two other papers, then one must consider those two cited papers have a co-citation relationship. The analysis of the co-citations allows researchers to perceive the structure and the development of a given research topic. By dividing the identified papers into clusters, using the network analysis method, it is possible to achieve the full set of characteristics of a research topic. Contrary to what one might think, in the reference co-citation network, the importance of the node—visually represented by its size and color depth—concerns the papers that are more closely related to the e-learning adoption topic (Fig. 10).

From the interpretation of Fig. 11, it is perceivable that the biggest nodes are Davis et al. [10], Davis [9], Ajzen [2], Venkatesh and Davis [50], and Venkatesh et al. [51]. A straightforward analysis of the highlighted papers shows that these are the original publications of the most relevant technology acceptance, adoption, and use theoretical models.

3.4.2 Journal co-citation analysis

The analysis of the journal co-citation network is important to understand the general structure of the subject and the characteristics of a journal. In Fig. 11, the network of co-citations of the journals, composed of 91 nodes, is shown. The node size represents the journal's activity, that is, the number of published papers on the topic. The proximity of the nodes allows us to observe the frequency of citation between journals, greater proximity, greater frequency. The journals "Computers and Education," "Computers in Human Behavior," "MIS Quarterly," "Information Systems Research," and "Information and Management" are the ones with the highest number of papers. Simultaneously, the existence of three clusters is noticeable, one in green that encompasses journals from the education area, one in red that represents the journals from the information systems area, and a third cluster—in blue—that includes the multidisciplinary journals that also cover the education topic. By observing the network, it is also possible to conclude that the proximity of the nodes between the "Computers and Education" and the "Computers in Human Behavior" journals, as well as between "MIS Quarterly," "Information and Management," and "Information Systems Research," represents the increased number of citations between them.

Table 3 lists the top 10 journals with the highest number of citations, as well as the subject area and category. It is noteworthy that "Computers and Education," "MIS

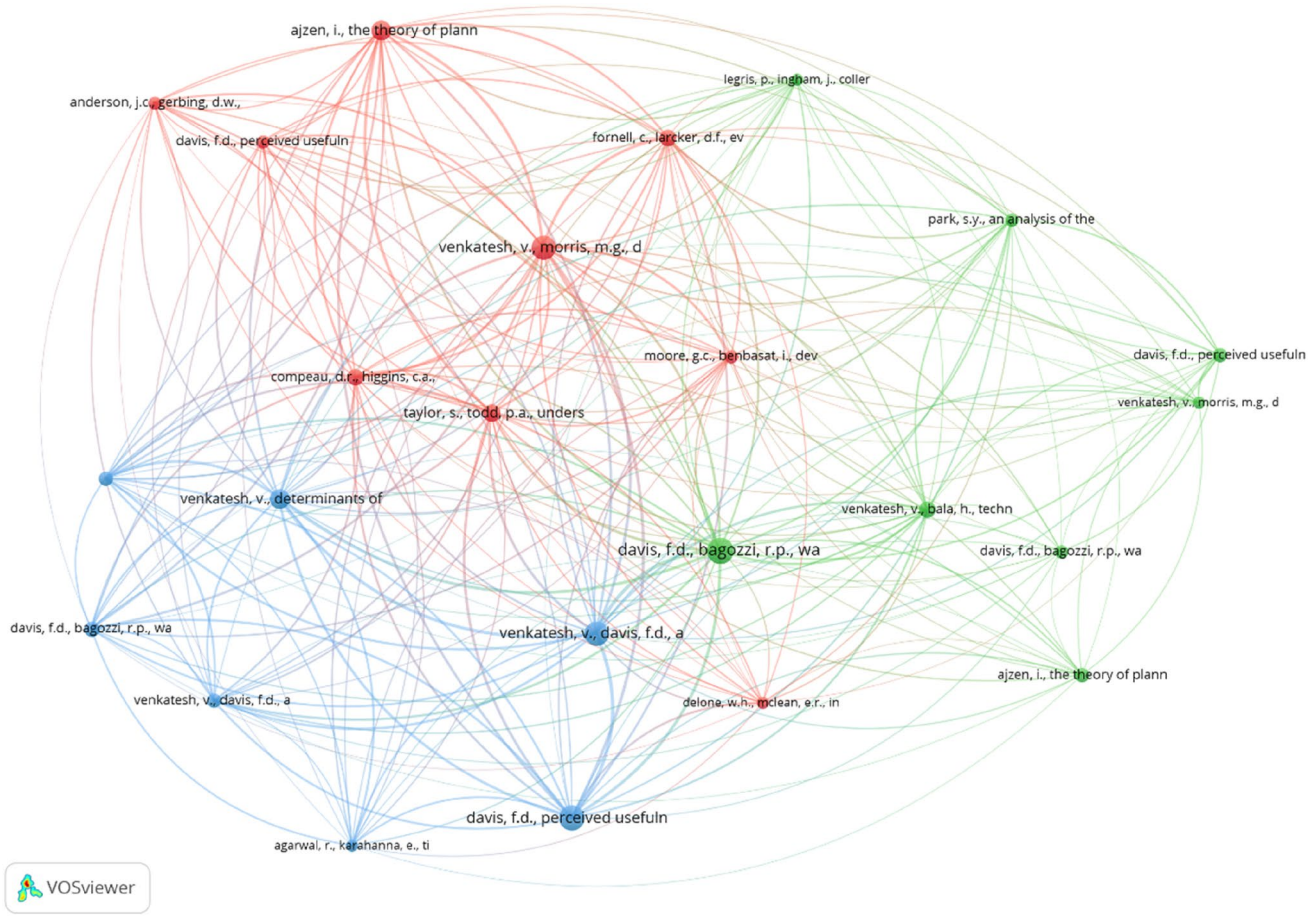

Fig. 10 The reference co-citation network of e-learning adoption models-related publications

Quarterly," and "Computers in Human Behavior" are the most-cited journals.

4 Discussion of the results

The aim of this research was the execution of a bibliometric analysis of e-learning adoption-related publications. Although the publications on the "e-learning" topic started to appear back in 1989, it is easily perceivable that until 2006 the growth in the number of papers being published on the adoption of this novel learning approach based on digital technologies is not significant. From 2006 to 2016, there was a significant increase in the number of publications; however, it was only after 2017 that the "e-learning adoption" topic started to be at the center of attention for the scientific community and the government bodies across the world, which led to exponential growth in the annual number of published papers.

Malaysia, Indonesia, and Hong Kong are the top 3 countries with the highest number of papers published on the e-learning adoption topic. "Computers and Education," "Computers in Human Behavior," and "Computer Applications in Engineering Education" are the top 3 journals with the most published papers, and, in what concerns papers published in conference proceedings, the most important proceedings on the topic (according to the number of published papers) are "Lecture Notes in Computer Science," "Proceedings of the International Conference on e-Learning," and "ACM International Conference Proceedings Series."

The analysis of the number of citations and inherent H-index allows us to perceive that Taiwan, Spain, and the UK are the top 10 most-cited countries and that the 3 countries with the biggest H-index (due to their e-learning adoption-related papers) are Taiwan, Malaysia, and the UK. The countries that cite the most are Malaysia, Taiwan, and China, respectively.

One of the most relevant components of a research paper is the set of keywords that classify it. Therefore, by analyzing the set of papers that composed the sample for this study, it was possible to realize that "e-learning," "students," and "technology acceptance model" are the top three keywords, with an aggregate of over 1500 occurrences. Considering

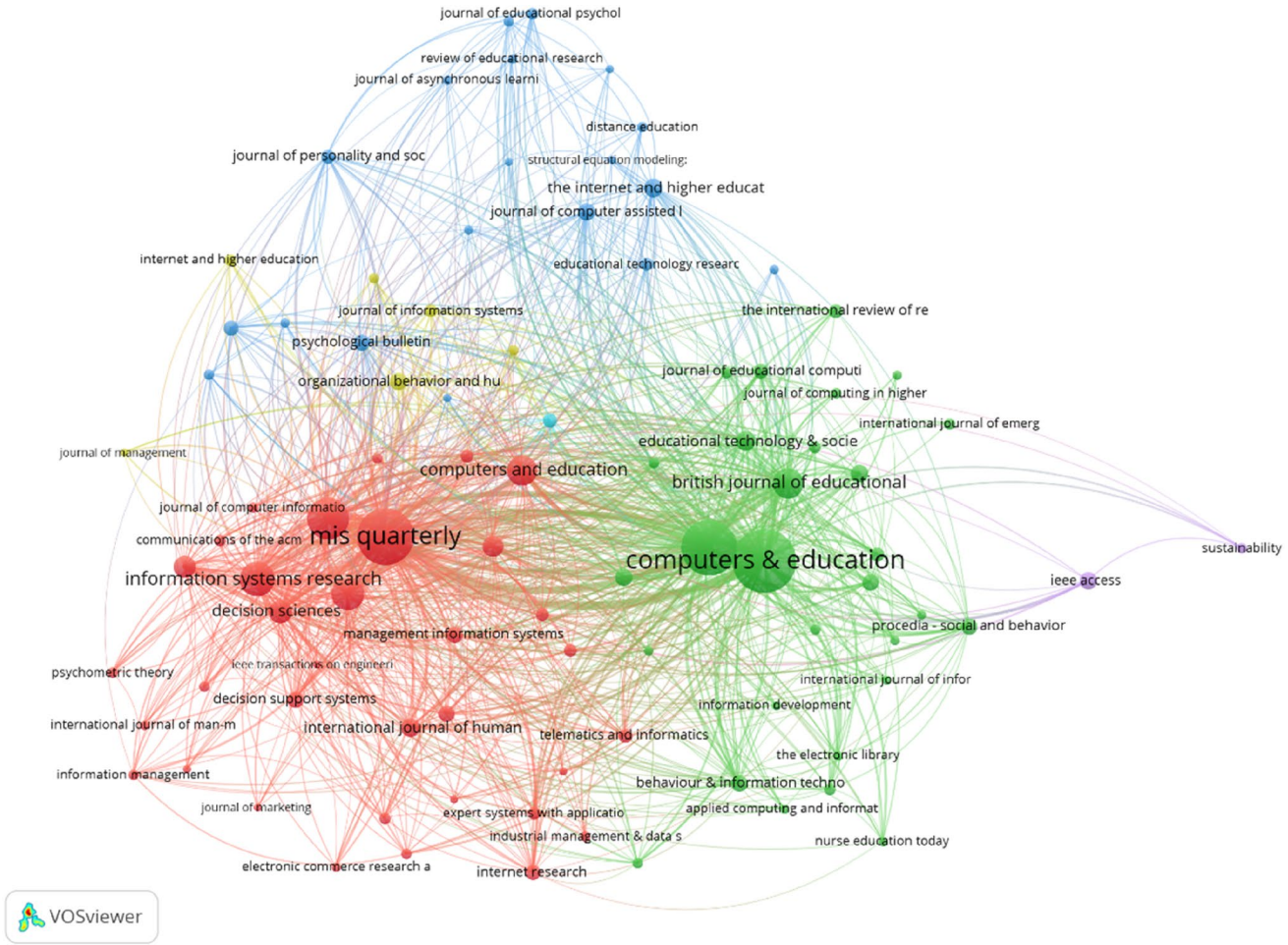

Fig. 11 The journal co-citation network of e-learning adoption models-related publications

that papers tend to have multiple keywords, it is relevant to analyze the strength of the relationship between those same keywords. Hence, the keywords relationships with the greatest strength are "e-learning" with "students," "e-learning" with "technology acceptance model," and "e-learning" with "learning systems."

Concerning the number of citations, the average number of citations for the study sample is 2.4, which indicates that each paper on the e-learning adoption topic is cited more than two times, on average. It is also interesting to state that the most-cited papers on the topic, by far, are documents published between 2004 and 2010 and that despite the number of publications has increased in the last decade this has yet to be reflected in the number of citations in the most recent papers. "Computers and Education," "British Journal of Educational Technology," and "Computers in Human Behavior" are the journals that published the e-learning adoption-related papers with the biggest number of citations.

By analyzing the study sample, we were also able to acknowledge that the journals that have published e-learning adoption-related papers might be divided into three clusters, one where "Education" is the focus, one that is more directed at publications from the information systems area, and a third one composed of multidisciplinary journals that encompass "Education" as one the topics on the journal's scope.

5 Conclusions

The present paper represents an additional demonstration that a bibliometric analysis might be considered a scientific method that produces valid results, namely a retrospective analysis of rich and vast research areas. As argued through the initial sections of the paper, the bibliometric methodology is establishing itself as a robust research methodology that can be of assistance to both senior and junior researchers.

The achieved results show that the e-learning adoption topic (that includes the acceptance, adoption, and use stages)

Table 3 Top 10 core journals

Journal	Subject	Citations
Computers and Education	Computer science | Computer science (miscellaneous) Social sciences | Education, e-learning	1372
MIS Quarterly	Business, management, and accounting | Management information systems Computer Science | Computer science applications, information systems Decision sciences | Information systems and management	918
Computers in Human Behavior	Arts and humanities | Arts and humanities (miscellaneous) Computer science | Human–computer interaction Psychology | Psychology (miscellaneous)	833
Information and Management	Business, management, and accounting | Management information systems Computer science | Information systems Decision sciences | Information systems and management	483
Information Systems Research	Business, management, and accounting | Management information systems Computer science | Computer networks and communications, information systems Decision sciences | Information systems and management Social sciences | Library and information sciences	325
Management Science	Business, management and accounting | Strategy and management Decision sciences | Management science and operations research	286
British Journal of Educational Technology	Social sciences | Education, e-learning	253
Decision Sciences	Business, management, and accounting | Business, management and accounting (miscellaneous), Management of technology and innovation, Strategy and Management decision sciences | Information systems and management	150
Journal of Management Information Systems	Business, management, and accounting | Management information systems Computer science | Computer science applications Decision sciences | Information systems and management, management science, and operations research	139
Journal of Marketing Research	Business, management, and accounting | Business and international management, marketing Economics, econometrics and finance | Economics and econometrics	122

is indeed relevant, and its overall importance has grown exponentially since 2017, to the point of reaching a sum of over 350 papers published during the last 3 years and collecting over 18,000 citations since the first paper on the topic was published back in 1989.

From a practical perspective, Malaysia and Indonesia were the countries that dedicated the most attention to the abovementioned topic. This has also been reflected in the institutions whose affiliates published the most, and where Malaysian and Indonesian universities are in a clear lead. It is also noticeable that the countries that most-cited papers on the e-learning adoption topic were Taiwan, Spain, the UK, the USA, and Malaysia, respectively. On the other hand, the countries with the biggest H-index (resulting from publications on the referred topic) were Taiwan, Malaysia, the UK, Spain, and the USA, respectively.

The journal with the largest number of publications on the topic is "Computers and Education," a first-quartile journal published by Elsevier focused on showcasing the existing knowledge and overall understanding of the impact digital technologies might have on education. The top 10 journals with the most publications are responsible for publishing 146 papers on the e-learning adoption topic, thus ensuring 36% of the total amount of journal articles composing the study sample. Through the analysis of papers published in conference proceedings, it was possible to conclude that "Lecture Notes in Computer Science" had the most publications. The top 10 conference proceedings with the most publications have published 31.5% (150) of the global amount of conference papers.

From a theoretical perspective, even though the e-learning adoption has been the focus of attention of multiple researchers worldwide for more than 20 years and practitioners already consider e-learning as something that is completely embedded in current education programs and organizations' activities, the analysis of the published papers demonstrates that this assumption has yet to be fully proven, as the acceptance and early-stage adoption are the issues that are most commonly addressed, including by the most recent literature.

5.1 Limitations and future research

Despite delivering, from our perspective, a bibliometric analysis of the existing literature on the e-learning adoption that represents a valuable insight into the current status of the topic, a deeper analysis of the used approach allows us to identify some limitations. The limitations can be justified by

the fact that we only used the Scopus database as the source of information, not including other relevant sources such as WoS, and the fact that we only addressed scientific papers, thus ignoring the existing gray literature on the topic that could bring some interesting insights on the actual adoption and use of e-learning tools and applications. Therefore, future research will aim to broaden the scope of the bibliometric analysis carried out either through the inclusion of new sources of information not only, through the use of articles other than journal articles (conference articles, book chapters, and books), but also by extending the research to, for example, dissertations and theses. Considering the COVID-19 pandemic, which started in early-2020 and still forces students and professors are around the World to use e-learning, we would also believe it would be very interesting to include papers published in 2022 on the topic and, particularly, on the impact that it had to learn (e.g., efficiency, efficacy, universal access, etc.).

Despite its inequivalent value to both e-learning (adoption) researchers and practitioners, we recognize the performed analysis could be improved by including scientific records from other scientific repositories other than Scopus.

Also, after carefully considering the achieved results and highlighted implications, it is possible to perceive the added value of including an entirely novel section with a qualitative analysis (e.g., a Focus Group) on those results. From our perspective, this would allow for highly qualified experts to be able to deliver their own considerations on both the achieved results and on future developments on the e-learning adoption field of study.

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Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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