E-learning bibliometric analysis from 2015 to 2020

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Received: 6 May 2021 / Revised: 26 July 2021 / Accepted: 23 December 2021 /
Published online: 30 January 2022
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Abstract This study aims to comprehensively examine the e-learning research field by conducting a bibliometric analysis of 12,272 publications between 2015 and 2020 from the WoS database. The study aims to highlight collaborations between authors, universities, and countries in the field, to identify the most influential authors, universities, countries, and reference papers; to know the research topics on which researchers have been working in recent years, and to examine African contribution in the field. The findings showed that the USA, Spain, England, and China are the most productive countries on e-learning. A. Tarhini is the most influential author, and e-Learning researchers host Universities are mainly from the UK, USA, and China. Computers in Human Behavior, Computers & Education, and International Journal of Emerging Technologies in Learning are the most represented journals; Islamic Azad University, Universidade Nova de Lisboa, and King Abdulaziz University are the most influential universities. The analysis shows that the collaboration between authors, universities, and countries working on e-learning is low, and COVID-19 has a significant impact on e-learning. African contribution and research on e-learning and its security are feeble.

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Keywords Bibliometric analysis · Meta-analysis · E-learning · E-learning meta-analysis · E-learning analysis

Introduction

Education is profoundly impacted by the progressive introduction of information and communication technology (ICT), resulting in the design and build of e-learning, or smart learning environments (SLEs) on a global scale for educational technology (Alajmi et al., 2020). With the advent of COVID-19, educational institutions are obliged to offer courses or training at a distance (Dhawan, 2020; Hoq, 2020). For some institutions, it will be a matter of improving their systems. For others, it will consist of setting up systems that allow them to offer online training to their students locked in their residences.

E-learning, as electronic learning, uses modern multimedia Internet technologies to enhance the learning experience, or quality of learning by providing learners with easy access to resources and services on the one hand, and by facilitating remote exchanges and collaboration on the other hand. The terms mobile learning (m-learning), distance learning (d-learning), online learning, remote learning, online training, distance training, digital learning are sometimes used to describe e-learning. However, there is a difference between these concepts as Basak et al. (2018) mentions by giving the nuance between E-learning, M-learning and D-learning, Moore et al. (2011) also provide the difference between e-learning, online learning, and distance learning environments.

The academic and professional literature on e-learning has grown considerably in recent years (Huynh et al., 2020). A variety of topics and issues have been explored and discussed in various studies. Research on e-learning reaches across disciplines, including education, computer science, sociology, psychology, and management, demonstrating the field's multidisciplinary nature (Cheng et al., 2014). E-learning researchers come from many disciplines and work on many different topics. And every researcher, new and old, needs to know what the research trend is, which journal publishes more publications in the field, which countries and universities are involved in the research, which are the most influential papers that should be read, which are the best collaborations between countries, universities or researchers, which are the reference researchers that should be followed, what is the evolution of the field over the years. A thematic overview of related studies is necessary for a comprehensive understanding of this large and diversified research field. Our study adopted a bibliometric approach to analyze relevant scientific publications published between 2015 and 2020, to uncover the main research themes and influential entities of the field.

The following sections are as follows: related works, research methodology, data analysis, interpretation of the results obtained, followed by a discussion of the results and a conclusion.

Related works

Tibaná-Herrera et al. (2018a) performed a meta-analysis on the production of publications in e-learning between 2003 and 2015 using SCOPUS to identify the evolution of publications concerning e-learning. Their analysis showed that the journal “Social Science” produces many publications, and that the production of the journal “Computer Science” has unfortunately decreased considerably. The results obtained by Tibaná-Herrera et al., (2018a, 2018b) show that the research on e-learning is on the decrease, since the increase offered by the “Social Sciences” is not enough to compensate the decline in the contribution of “Computer Science.” Their study contributes to the description of e-learning, in its nature and dynamics of growth in the Social Sciences, and the behavior of related knowledge domains. Their work was limited to explaining the behavior or evolution of scientific production in e-learning from bibliographic metadata.

In September 2018, Tibaná-Herrera et al. (2018b) analyzed 39,244 documents indexed in Scopus and SCImago Institutional Rankings between 2003 and 2016. Their analysis showed that the United States produces most of the research at the country level, and generates the largest number of publications, and the most significant international collaboration. At the institutional level, the University of Hong Kong is the most productive, and the National Taiwan University of Science and Technology is the most collaborative. The authors highlighted extensive collaboration at the national and institutional level, which has facilitated a 56% increase in scientific output in this area over the past five years. Their result reveals the consolidation of four clusters directly related to the development of e-learning: North America, Western Europe, Australia, and Taiwan.

Based on 108 articles, Chen et al., (2020a, 2020b) conducted a bibliometric analysis of the journal Smart Learning Environments (SLE) articles to obtain an in-depth examination of the status and trends of SLE research from 2014 to 2019. SLE articles’ trend analysis indicated that the annual SLE article number had grown from 7 to 29. The “learning environment,” “smart learning environment,” “learning process,” and “learning analytics” were the most frequently used key phrases. The most prolific countries in the field of “Smart Learning” are the USA, Canada, China, Taiwan, and Turkey; and the most prolific universities are the University of North Texas (USA), Athabasca University (Canada), Beijing Normal University (China), Hacettepe University (Turkey), and National Sun Yat-Sen University (Taiwan).

Chen et al. (2021) conducted a study to thoroughly examine the research area of smart learning by performing a thematic modeling analysis of 555 publications on smart learning collected in the Scopus database, an extension of the research of Chen et al., (2020a, 2020b). Their study to learn about influencers in the smart learning field revealed that China is the most productive country, and Tsinghua University is the most productive institution for publishing research on smart learning. The predominant research topics include mobile learning, blended learning for smart learning, IoT and cloud computing, ecosystem and ambient intelligence, and MOOCs and course content management.

A total of 5167 publications were analyzed by Goksu (2021) in September 2019 on “mobile learning” using metadata from WoS. As a result of the bibliometric analysis, it was concluded that the most active countries in mobile learning are Taiwan, the USA, China and England. According to the keyword co-occurrence analysis, mobile devices, higher education, mobile technologies, tablets and smartphones stand out in the field of mobile learning. During the 2015–2019 period, the trending topics overall were educational technologies and, more specifically, tablets, cell phones, MOOCs, and learning strategies. It was found that Hwang is the most influential researcher, and the National Taiwan University of Science and Technology is the most influential. According to the analyses conducted in journals, “Computers & Education,” “British Journal of Educational Technology,” and “Educational Technology & Society” are the most contributing journals. In addition to the parameters such as citation and TLS calculated using VoSViewer and Scimat, the author also used the h-index for ranking the influential entities using Harzing’s Publish and Perish’s software.

Cheng et al. (2014) conducted a bibliometric analysis on e-learning at the workplace on research published between 2000 and 2012 by examining 324 articles published in academic journals and conference proceedings. Their results identify six research themes in the field, which are then classified into four dimensions. The themes are e-learning for continuing education and professional development, e-learning in healthcare, using social media for e-learning, and integrating knowledge management with e-learning. The four dimensions highlighted by the authors are e-learning for continuing education and professional development, e-learning in the health care sector (as one of the most prolific e-learning initiatives), the use of social media for learning, and the integration of knowledge management into e-learning.

In order to have a comprehensive overview of “Classroom dialogue,” Song et al. (2019) conducted a bibliometric analysis on 3914 papers published between 1999 and 2018 retrieved from the WoS database. The authors’ results show that publications and citations related to classroom dialogue have increased significantly over the past 20 years, and that the USA has contributed spectacularly to the increase in publications, especially since 2012. Computers & Education, and Journal of Research in Science Teaching are the two most prestigious journals according to (Song et al., 2019). Thematic characteristics related to classroom dialogue research were revealed through keyword analysis. Several frequent keywords were identified by authors throughout the period, e.g., “classroom,” “discourse,” “student”) and, at the parallel, new keywords emerged such as “technology,” “computer-mediated communication,” which reflect changing trends in the field.

On the celebration of the 50th anniversary of the British Journal of Educational Technology (BJET), Chen et al., (2020a, 2020b) conducted a bibliometric analysis in order to see an overview of the impact of the journal in its domain. For this purpose, they performed a bibliometric analysis of the 3 710 publications of this journal from 1971 to 2018 as indexed in the Web of Science. UK, USA, Australia, Taiwan, and Canada are the most prolific country according to h-index value, citations and number of publications. Their findings highlighted several research hotspots and emerging topics such as technology-enhanced classroom

pedagogy, blended learning, online social communities, mobile-assisted language learning, game-based learning, and socialized online learning. Based on the authors' research findings, BJET has played an increasingly important role in the field of educational technology, and it will continue to play a leading role in this field in the future (Chen et al., 2020a, 2020b).

Chen et al. (2019) carried out a study analyzing the status and trends of research in educational technology to get a comprehensive review of articles on educational technology over the last 40 years. Their study is a bibliometric analysis of research topics, author profiles, and collaboration networks using a leading journal, *Computers & Education*. The authors used the WoS database, retrieving 3,963 articles published by the journal during the period 1978–2018. The yearly distribution of articles shows a meaningful growth of the journal's publications, especially between 2005 and 2011. The analysis of the evolution of keywords highlights some predominant topics such as “interactive learning environment,” “teaching/learning strategies,” “pedagogical issue,” and “improving classroom teaching.”

Research methodology

Research aim

When investigating “e-learning” in the literature, we can notice a considerable amount of research conducted by the scientific community on the subject. By examining the literature closely, we notice that there are bibliometric analyses or literature reviews on “e-learning”. All these studies show that research on “e-learning” has increased over the years. This means that “e-learning” is an exciting, important and promising field, especially with the arrival of COVID-19 where we are experiencing lockdown or quarantine. The only way to reduce the virus's spread while still pursuing studies is through distance learning or online training.

Although there are a significant number of studies on “e-learning,” or “mobile learning,” or “online learning,” or “distance learning,” none are conducted on bibliometric analysis or meta-analysis in recent years. This paper aims to perform a meta-analysis of the “e-learning” research work from 2015 to 2020 using bibliometric metadata. The field analysis will be done according to variables such as keywords, authors, countries, citations, publications, universities, and journals. It will be a question of knowing:

1. What is the co-authorship's status?
2. Who are the most influential authors?
3. Which are the most influential publications?
4. Which are the most influential journals?
5. Which are the most influential countries and universities?

6. What is keywords' distribution and trend?
7. What is the African countries' contribution on “e-learning” researches?

Research design

This study is carried out according to an approach of analysis of bibliometric data of scientific publications dealing with “e-learning”. The analysis focuses on two parts: (1) bibliometric mapping to examine the trends in e-learning, and (2) analysis of keywords indexed in the articles to identify research groups and to understand the research themes associated with e-learning.

Obtaining data set

To perform our study, the bibliographic database Web of Science (WoS) was used for its coverage and peer review of its indexed publications (Birkle et al., 2020). WoS was used to extract a representative set of relevant literature using the keyword “e-learning”, covering 2015 to 2020 from Web of Science Core Collection. The following search query was constructed and applied in the database: *TOPIC: (“e-learning”) Timespan: 2015–2020. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC*. WoS was consulted on March 12, 2021, and a total of 12,272 publications were obtained. The data set we used, consists of 25 different “.txt” files since WoS allows downloading up to 500 records simultaneously.

Data analysis

Analyses of co-authorship, bibliographic coupling, keyword co-occurrence, and citation were performed on bibliometric meta-data using VOSViewer software. For bibliographic coupling, the relationships of elements such as publications, journals and authors, are determined according to the number of shared resources, i.e., a reference to the same publication in two different sources is considered bibliographic coupling. The analysis of the co-occurrence of keywords reveals the evolution of the domain over time (Deng & Xia, 2020). It is therefore an efficient method to identify hot topics in a given research domain. Citation analysis helps researchers to detect popular research topics and papers that other researchers work on (Lai, 2020). The results of the analysis are presented in the form of a table or network visualization map.

Figure 1 shows the number of e-learning publications published each year between 2015 and 2020. Figure show that research on e-learning is significant and relatively stable, ranging from 2244 (2015) to 2265 (2016). There were 2244 articles published in 2015, representing 18.286% of publications; 2265 publications in 2016, representing 18.457%; 2,116 publications in 2017, representing 17.243%; 2078 publications in 2018, representing 16.933%; 2,010 publications in 2019, representing 16.379% of publications, and 1559 publications in 2020, representing 12.704% of publications. We notice that, more articles were published in 2015 and 2016, and

Fig. 1 Publication on e-learning research according to years

less in 2020, the year in which we expected to have more publications on e-learning as it was one of the solutions to ensure the continuity of learning during COVID-19. Furthermore, we can observe that the number of publications decreases over time.

It was found with the analysis of the data set that the publications related to e-learning cover 151 countries, mainly Spain (8.263%), USA (7.456%), England (5.566%), China (5.231%), Romania (4.824%), Germany (4.759%), India (4.685%), Russia (4.278%), Italy (3.251%), etc. as we can see on Fig. 2. The analysis also reveals that the publications were written in 24 languages, of which 95.013% in

Fig. 2 Publication on e-learning research according to countries

Fig. 3 Publication on e-learning research according to languages

Fig. 4 Publication on e-learning according to document type

English (11,660 publications), 2.200% in Spanish (270 publications), 0.750% in Russian (92 publications), 0.619% in Portuguese (76 publications), 0.538% in German (66 publications), 0.236% in French (29 publications), 0.147% in Polish (18 publications), 0.090% in Italian (11 publications) as we can see on Fig. 3.

Figure 4 shows the types of papers published on e-learning between 2015 and 2020. We notice that 49.242% are “Proceedings Paper” (6043 publications), 45.347% of the publications are “Article” (5565 publications), 2.396% are “Book Chapter” (294 publications), 2.339% are “Review” (287 publications), 1.589% are “Meeting Abstract”, i.e., 195 publications. Figure 5 shows the areas of research that are interested in e-learning. Among these areas, we have mainly “Education Educational Research” which produced 5948 publications out of 12,272 publications, i.e., 48.468% of the publications between 2015 and 2020; “Computer Science” which produced 3632 publications (29.596%); “Engineering” produced 1692 publications (13.787%); “Telecommunications” published 456 publications (3.716%); “Economic Business” published 447 publications (3.642%).

Regarding the organizations, institutions or universities that provide a great work on e-learning, we have mainly “UNIV POLITEHN BUCURESTI” (University Politehnica of Bucharest from Romania) 115 publications, i.e., 0.937%; “UNIV HRADEC KRALOVE” (University of Hradec Kralove from Czech Republic) with 66 publications, i.e., 0.538%; “UNIV HONG KONG” (University of Hong Kong) 57 publications, i.e., 0.464%; “KING ABDULAZIZ UNIV” (King Abdulaziz University from Saudi Arabia) with 53 publications, i.e., 0.432%; “UNIV COMPLUTENSE MADRID” (Complutense University of Madrid from Spain) with 52 publications, i.e., 0.424% (see Fig. 6).

C. Radu published 28 publications (0.228%), M. Virvou 27 publications (0.220%), S. Lujan-Mora 25 publications (0.204%), C. Meinel 25 publications (0.204%), I. Simonova 24 publications (0.196%), H. B. Santoso 22 publications (0.179%), M. Montebello 21 publications (0.171%), C. Troussas 21 publications (0.171%), M. Ivanovic 20 publications, i.e., 0.163% (see Fig. 7).

Fig. 5 Publication on e-learning according to research areas

Fig. 6 Publication on e-learning according to organizations

Fig. 7 Publication on e-learning according to authors

Results

Co-authorship status

For the analysis of collaboration between authors on e-learning, authors with at least 5 publications were included, which allowed us to go from 31,445 authors to 410 authors. The analysis revealed 211 different groups (see Fig. 8), in which only 3 groups were connected (see Fig. 9), and a few researchers provided this

Fig. 8 Co-authorship network map in e-learning

Fig. 9 Co-authorship connected clusters map in e-learning

connection. As shown in Fig. 8, the relevant cooperative author groups are presented in different colors and represent the focus of e-learning research. When we examine the co-authorship network visualization map in Fig. 8, we understand that the cooperation between researchers working on e-learning is low even though there are enough authors.

Also, the number of active researchers is weak in most groups. For example, out of the 211 groups, the most important groups are composed of 3 groups of 8 authors, 2 groups of 7 authors, 4 groups of 6 authors, 5 groups of 5 authors, 9 groups of 4 authors, 18 groups of 3 authors, 56 groups of 2 authors, and 110 single authors.

The largest group is the red cluster composed of 8 authors, among which authors with more publications are S. Caballe (17 publications), F. Xhafa (10 publications), and J. Miguel (10 publications). The second group is the green one, also composed of 8 authors. The most prominent in this group are H. Xie (17 publications), L. F. Wang (15 publications), and D. Zou (15 publications). The third-largest group is the one in blue. In this group of 8 authors, E. Smyrnova-Trybulska stands out with 13 publications, and N. Morz (12 publications).

The co-authorship analysis conducted to determine the cooperation of researchers on a country basis in e-learning, takes into account countries with more than 5 publications. This analysis revealed that only 107 countries out of 150 met this criterion and formed 11 different co-author groups. It was found that 106 other countries, except for Moldova, were connected to the network. It should be noted that among the 107 connected countries, Israel is alone in its cluster.

Figure 10 shows the countries whose authors collaborate on e-learning. The fact that the clusters showing the countries in which authors collaborate the most, is not very different from each other shows that researchers are working together on e-learning worldwide. At the end of the graph, the countries that have weak cooperation with other countries/clusters in the network, are generally developing countries. According to total link strength (TLS) value, the most influential countries in terms of collaboration are England, the USA, Spain, Italy, Germany, Australia, China, Netherlands, France, Canada, Portugal, and Belgium. Remarkably, Germany, Russia, Romania, and Italy belong to the same group. On the other hand, India and the USA also belong to the same group, and Australia and China are members of the same group.

Most influential researchers

As a result of the citation analysis, including authors with at least 5 publications, it was observed that the top 20 authors with the highest TLS value were ranked in the Table 1. It can be seen that N. Q. Naveed is the most influential author. Besides, H. Xie, D. Zou, A. Shah and N. R. Mohamed Qureshi also distinguished themselves. Usually, researchers in e-learning are those working in universities in the UK, USA, and China.

Ranked by citations, the top 10 researchers are A. Tarhini, M. Aparicio, T. Oliveira, K. J. Tarus, Z. Niu, K. Ahmed, P. Dasgupta, R. M. Fischer, and J. Luis Fernandez-Aleman (see Table 2). Furthermore, when ranked by the number of publications (Fig. 7), only few researchers are found in the top 20 ranked by TLS or citations. This result shows that although there is much research on e-learning, researchers do not reach the expected interest in this field, and that publishing more papers does not necessarily mean that an author is the most influential. We have to consider the number of citations and TLS. By combining these parameters, we can claim that A. Tarhini is the most influential author with 9 papers cited 320 times and 49 as TLS value.

Fig. 10 The country co-authorship in e-learning

Most influential papers

From the 12 272 publications analyzed, only 74 papers are cited more than 50 times. The top 15 most influential publications are presented in Table 3. The analysis of Table 3 shows that the research on e-learning focuses much more on the learner: the social aspect, the learner experience, the impact of e-learning on the learner's learning, and how to improve the learning. The article by J. Lu, et al. entitled "Recommender system application developments: A survey" published in the journal "Decision Support Systems" in 2015 is the most cited article in e-learning (468 times in WoS and 1018 times in Google Scholar). The second most cited paper is J. L. Jensen et al. entitled "Improvements from a Flipped Classroom May Simply Be the Fruits of Active Learning" also published in 2015 in the journal "CBE-Life Sciences Education," cited 255 times in WoS and 721 times in Google Scholar. The third most

Table 1 Most influential researchers in e-learning ranked by TLS

Rank	Author	Country	Papers	Cites	TLS
1	N. Q. Naveed	Saudi Arabia	10	63	85
2	H. Xie	Hong Kong	17	58	73
3	D. Zou	Hong Kong	15	52	72
4	A. Shah	Malaysia	9	44	72
5	N. R. Mohamed Qureshi	Saudi Arabia	5	41	60
6	S. Sanober	Saudi Arabia	5	41	56
7	B. Kolodziejczak	Poland	9	29	59
8	M. Roszak	Poland	9	29	59
9	L. F. Wang	Hong Kong	15	30	53
10	A. Al-Abri	Oman	6	6	52
11	Y. Jamoussi	Oman	6	6	52
12	N. Kraiem	Oman	6	6	52
13	A. Tarhini	Oman	9	320	49
14	N. Ahmad	Saudi Arabia	5	19	47
15	K. J. Tarus	Kenya	6	203	46
16	M. Injadat	Canada	5	28	42
17	A. Moubayed	Canada	5	28	42
18	A. Shami	Canada	5	28	42
19	M. Nakazawa	Japan	7	8	42
20	S. Hirasawa	Japan	7	8	42

cited paper is by H. Mohammadi et al. whose title is “Investigating users’ perspectives on e-learning: An integration of TAM and IS success model” also published in 2015 in the journal “Computers in Human Behavior,” cited 176 times in WoS and 464 times in Google Scholar.

The analysis also revealed that the most cited papers are the oldest, as most of the popular papers are published in 2015 and 2016, and the most recent in the top 15 is published in 2017. However, there is one Hot Paper, by Blake et al. whose title is “Mitigating the Psychological Impact of COVID-19 on Healthcare Workers: A Digital Learning Package” published in 2020 in the journal “International Journal of Environmental Research and Public Health,” cited 58 times in WoS and 156 times in Google Scholar.

Among the most cited papers, there are some that deal with literature review, or systematic literature review, or metanalysis, which shows the importance of social and experimental research in e-learning, and therefore the importance of review studies.

Most influential journals

To determine the most influential journal that published papers on e-learning, a citation analysis was performed. Out of 4129 sources, only 177 journals/publishers

Table 2 Most influential researchers in e-learning ranked by citation

Rank	Author	Country	Papers	Cites	TLS
1	A. Tarhini	Oman	9	320	49
2	M. Aparicio	Portugal	6	251	38
3	T. Oliveira	Portugal	5	249	38
4	J. N. Navimipour	Tehran	5	244	12
5	K. J. Tarus	Kenya	6	203	46
6	Z. Niu	USA	8	203	40
7	K. Ahmed	UK	6	203	10
8	P. Dasgupta	UK	5	178	18
9	R. M. Fischer	Germany	7	152	7
10	J. Luis Fernandez-Aleman	Spain	5	148	0
11	J. F. Garcia-Penalvo	Spain	5	132	5
12	K. Sostmann	Germany	5	125	7
13	E. Kurilovas	Lithuania	11	116	3
14	M. Ivanovic	Serbia	18	112	19
15	A. Klasnja-Milicevic	Serbia	17	107	26
16	C. W. Tsai	Taiwan	13	100	12
17	L. De-Marcos	Spain	7	99	29
18	A. Garcia-Cabot	Spain	6	97	29
19	E. Garcia-Lopez	Spain	6	97	29
20	F. Jose Garcia-Penalvo	Spain	5	94	6

published at least 10 papers on e-learning between 2015 and 2020. Following the citation analysis, the top 20 journals with the highest TLS value are listed in Table 4, and the top 20 journals with the highest citations in Table 5.

Examining Table 4, the journal with the highest TLS value is “Computers in Human Behavior.” In addition to the related journal, “Computers & Education,” “Education and Information Technologies,” “International Journal of Emerging Technologies in Learning,” and “IEEE Access” were the leading journals. When Table 5 is examined, the journal with the highest citations is “Computers in Human Behavior.” The second journal is “Computers & Education” again. In addition to these related journals, “BMC Medical Education,” “British Journal of Educational Technology,” and “International Journal of Emerging Technologies in Learning” were the leading journals.

The observation of Tables 4 and 5 reveals that “Computers in Human Behavior” is the most influential journal, followed by “Computers & Education,” and “International Journal of Emerging Technologies in Learning”.

Most influential countries

To identify the most influential country in e-learning research, a citation analysis was performed considering the number of citations and the TLS value. It was found that research is being conducted on e-learning in 151 different countries. The top 20

Table 3 Most cited papers in e-learning

Rank	Papers	WoS cites	GS ^a cites
1	Lu, J., Wu, D., Mao, M., Wang, W., & Zhang, G. (2015). Recommender system application developments: a survey. <i>Decision Support Systems</i> , 74, 12–32	468	1018
2	Jensen, J. L., Kummer, T. A., & Godoy, P. D. M. (2015). Improvements from a flipped classroom may simply be the fruits of active learning. <i>CBE—Life Sciences Education</i> , 14(1), ar5	255	721
3	Mohammadi, H. (2015). Investigating users' perspectives on e-learning: An integration of TAM and IS success model. <i>Computers in human behavior</i> , 45, 359–374	176	464
4	Abdullah, F., & Ward, R. (2016). Developing a General Extended Technology Acceptance Model for E-Learning (GETAMEL) by analysing commonly used external factors. <i>Computers in human behavior</i> , 56, 238–256	167	451
5	Truong, H. M. (2016). Integrating learning styles and adaptive e-learning system: Current developments, problems and opportunities. <i>Computers in human behavior</i> , 55, 1185–1193	140	445
6	McCutcheon, K., Lohan, M., Traynor, M., & Martin, D. (2015). A systematic review evaluating the impact of online or blended learning vs. face-to-face learning of clinical skills in undergraduate nurse education. <i>Journal of advanced nursing</i> , 71(2), 255–270	140	380
7	Sardi, L., Idri, A., & Fernández-Alemán, J. L. (2017). A systematic review of gamification in e-Health. <i>Journal of biomedical informatics</i> , 71, 31–48	140	334
8	Liu, Q., Peng, W., Zhang, F., Hu, R., Li, Y., & Yan, W. (2016). The effectiveness of blended learning in health professions: Systematic review and meta-analysis. <i>Journal of medical Internet research</i> , 18(1), e2	136	314
9	Thai, N. T. T., De Wever, B., & Valcke, M. (2017). The impact of a flipped classroom design on learning performance in higher education: Looking for the best “blend” of lectures and guiding questions with feedback. <i>Computers & Education</i> , 107, 113–126	124	349
10	Abdullah, F., Ward, R., & Ahmed, E. (2016). Investigating the influence of the most commonly used external variables of TAM on students' Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) of e-portfolios. <i>Computers in human behavior</i> , 63, 75–90	99	252
11	Bayne, S. (2015). What's the matter with 'technology-enhanced learning'? <i>Learning, Media and Technology</i> , 40(1), 5–20	91	230
12	Al-Zahrani, A. M. (2015). From passive to active: The impact of the flipped classroom through social learning platforms on higher education students' creative thinking. <i>British Journal of Educational Technology</i> , 46(6), 1133–1148	88	267

Table 3 (continued)

Rank	Papers	WoS cites	GS ^a cites
13	Manca, S., & Ranieri, M. (2016). “Yes for sharing, no for teaching!”: Social Media in academic practices. <i>The Internet and Higher Education</i> , 29, 63–74	88	212
14	Sinclair, P. M., Kable, A., Levett-Jones, T., & Booth, D. (2016). The effectiveness of Internet-based e-learning on clinician behaviour and patient outcomes: A systematic review. <i>International journal of nursing studies</i> , 57, 70–81	88	196
15	Navimipour, N. J., & Zareie, B. (2015). A model for assessing the impact of e-learning systems on employees’ satisfaction. <i>Computers in Human Behavior</i> , 53, 475–485	87	182

GS cites Google Scholar number of citations

Table 4 Most influential Journal in e-learning ranked by TLS

Rank	Journal	Papers	WoS Cites	TLS
1	Computers in Human Behavior	73	2284	434
2	Computers & Education	52	1271	296
3	Education and Information Technologies	112	468	216
4	International Journal of Emerging Technologies in Learning	175	594	195
5	IEEE Access	58	323	175
6	Interactive Learning Environments	52	485	151
7	International Review of Research in Open and Distributed Learning	60	514	141
8	British Journal of Educational Technology	44	623	118
9	BMC Medical Education	73	703	99
10	International Journal of Advanced Computer Science and Applications	102	158	97
11	Sustainability	45	144	89
12	Journal of Medical Internet Research	35	498	84
13	Interactive Technology and Smart Education	35	139	84
14	Electronic Journal of E-learning	50	304	80
15	Journal of Information Technology Education-Research	19	62	74
16	Turkish Online Journal of Distance Education	65	86	73
17	Telematics and Informatics	19	359	69
18	Educational Technology & Society	35	303	64
19	Plos One	23	181	63
20	Computer Applications in Engineering Education	52	231	59

influential countries in e-learning with the highest citations in Table 6, and the top 20 influential countries with the highest TLS value are presented in Table 7.

Observing Table 6, the most cited country is the USA, followed by Spain, England, Australia, and China. However, the country with the highest TLS value is England, followed by the USA, Spain, China, and Malaysia. By considering the value of TLS and the number of citations, we can claim that the most influential countries are the USA, Spain, England, and China.

Most influential universities

More than 8757 universities/institutions have researched e-learning between 2015 and 2020. Citation analysis was performed on the 8757 universities to know which one is the most influential working on e-learning. The top 20 influential universities with the highest citations in Table 8 and the top 20 influential universities with the highest TLS value are presented in Table 9. The *University of Technology of Sydney* is the most cited (with the most cited papers). It is also remarkable to see that it is one of the universities with few papers published in the top 20, but is nevertheless the most cited according to Table 8. Other than this university, the most cited universities are *Islamic Azad University*, *University of Malaya*, *Universidade Nova de*

Table 5 Most influential Journal in e-learning ranked by citations

Rank	Journal	Papers	WoS Cites	TLS
1	Computers in Human Behavior	73	2284	434
2	Computers & Education	52	1271	296
3	BMC Medical Education	73	703	99
4	British Journal of Educational Technology	44	623	118
5	International Journal of Emerging Technologies in Learning	175	594	195
6	International Review of Research in Open and Distributed Learning	60	514	141
7	Anatomical Sciences Education	35	510	21
8	Journal of Medical Internet Research	35	498	84
9	Interactive Learning Environments	52	485	151
10	Education and Information Technologies	112	468	216
11	Telematics and Informatics	19	359	69
12	IEEE Access	58	323	175
13	Electronic Journal of E-learning	50	304	80
14	Educational Technology & Society	35	303	64
15	Nurse Education Today	28	272	35
16	Internet and Higher Education	6	260	52
17	Educational Technology Research and Development	6	260	52
18	IEEE Transactions on Learning Technologies	29	233	39
19	Computer Applications in Engineering Education	52	231	59
20	Medical Teacher	28	205	46

Lisboa, and the *University of Pittsburgh*. Regarding the universities with the highest TLS value, we have *King Abdulaziz University* in the first rank. In addition to the related university, *King Khalid University*, *Universidade Nova de Lisboa*, *King Saud University*, and *Islamic Azad University* were the leading according to Table 9.

By combining the two parameters (citations and TLS value), we can claim that *Islamic Azad University*, *Universidade Nova de Lisboa*, and *King Abdulaziz University* are the most influential universities.

The keywords analysis and e-learning trend topics

A total of 24843 keywords were used in 12272 publications dealing with e-learning. According to the co-occurrence analysis performed on the keywords, only 908 keywords appear in more than 10 publications. The cooccurrence analysis revealed that the keywords are grouped in 8 clusters or groups, as shown in Fig. 11. The keywords in the clusters give information about related research topics in the area of interest (Goksu, 2021).

As seen in Fig. 11, the largest cluster is the red cluster with 208 keywords. Words like learning analytics, design, system, learning management system, collaborative learning, adaptive learning, personalization, ontology, semantic web, data mining, and machine learning are highlighted. The green cluster

Table 6 Most influential countries in e-learning ranked by citations

Rank	Country	Documents	WoS cites	TLS
1	USA	912	4363	1215
2	Spain	1013	3817	1185
3	England (UK)	682	3803	1441
4	Australia	380	2771	852
5	China	640	2372	1021
6	Germany	583	1832	670
7	Italy	398	1616	644
8	Canada	300	1605	550
9	India	675	1423	807
10	Taiwan	319	1399	421
11	Malaysia	360	1159	946
12	Netherlands	204	1064	392
13	Iran	163	1056	530
14	Saudi Arabia	286	929	795
15	Turkey	187	883	485
16	Portugal	278	873	516
17	Russia	524	862	353
18	Brazil	223	795	313
19	Belgium	122	773	262
20	Romania	591	674	326

Table 7 Most influential countries in e-learning ranked by TLS

Rank	Country	Documents	WoS cites	TLS
1	England (UK)	682	3803	1441
2	USA	912	4363	1215
3	Spain	1013	3817	1185
4	China	640	2372	1021
5	Malaysia	360	1159	946
6	Australia	380	2771	852
7	India	675	1423	807
8	Saudi Arabia	286	929	795
9	Germany	583	1832	670
10	Italy	398	1616	644
11	Canada	300	1605	550
12	Iran	163	1056	530
13	Portugal	278	873	516
14	Turkey	187	883	485
15	Taiwan	319	1399	421
16	Netherlands	204	1064	392
17	Pakistan	110	397	363
18	Russia	524	862	353
19	Romania	591	674	326
20	Indonesia	387	317	320

Table 8 Most influential universities in e-learning ranked by citations

Rank	University	Country	Papers	WoS cites	TLS
1	University of Technology of Sydney	Australia	19	574	55
2	Islamic Azad University	Iran	43	366	95
3	University of Malaya	Malaysia	43	360	70
4	Universidade Nova de Lisboa	Portugal	21	341	103
5	University of Pittsburgh	USA	29	315	52
6	King Abdulaziz University	Saudi Arabia	52	302	144
7	University of Salamanca	Spain	33	296	46
8	Sultan Qaboos University	Oman	25	281	63
9	Beijing Institute of Technology	China	13	273	47
10	King's College London	England (UK)	29	269	29
11	University of Murcia	Spain	24	263	32
12	King Saud University	Saudi Arabia	30	262	102
13	University of Warwick	USA	21	248	42
14	University of Granada	Spain	48	232	62
15	University of Sydney	Australia	26	322	31
16	University of Alcala	Spain	26	231	61
17	University of Copenhagen	Denmark	19	230	21
18	University of British Columbia	Canada	25	228	37
19	National Distance Education University	Spain	19	222	44
20	Vrije Universiteit Amsterdam	Netherlands	25	221	62

is the second one with 166 keywords. These include e-learning, higher education, university, blended learning, online learning, distance education, lifelong learning, gamification, moodle, MOOC, mobile learning, and cloud computing are predominant. In the third cluster, the blue cluster, with 163 keywords, education, impact, knowledge, internet, attitudes, program, behavior, evaluation, skills, care, quality, simulation, and information, was the most used keywords. And the fourth-largest cluster is the one in yellow, with 118 keywords, model, satisfaction, adoption, acceptance, information technology, user acceptance, user satisfaction, technology acceptance model, perceptions, and success were the most used. In other clusters, the most popular keywords are students, performance motivation, online, higher education, engagement, achievement, Environments, and framework for the purple cluster (97 keywords); technology, augmented reality, virtual reality, innovation, Facebook, innovation, integration, medical education, medical students, platform, social media, undergraduate education, web-based learning for the turquoise cluster (77 keywords); collaboration, distance learning, engineering education, game-based learning, online education, and sciences in the orange cluster (66 keywords); challenges, e-assessment, and expectations in the gray cluster (13 keywords). These findings highlight the importance of e-learning in education or higher education and the importance of using technology in education to improve students' learning experience via the integration of collaboration tools and artificial intelligence.

Table 9 Most influential universities in e-learning ranked by TLS

Rank	University	Country	Papers	WoS cites	TLS
1	King Abdulaziz University	Saudi Arabia	52	302	144
2	King Khalid University	Saudi Arabia	23	87	123
3	Universidade Nova de Lisboa	Portugal	21	341	103
4	King Saud University	Saudi Arabia	30	262	102
5	Islamic Azad University	Iran	43	366	95
6	University Sains Malaysia	Malaysia	40	178	94
7	International Islamic University Malaysia	Malaysia	14	48	75
8	University of Malaya	Malaysia	43	360	70
9	Sultan Qaboos University	Oman	25	281	63
10	University of Granada	Spain	48	232	62
11	Vrije Universiteit Amsterdam	Netherlands	25	221	62
12	University of Alcalá	Spain	26	231	61
13	University of Technology, Malaysia	Malaysia	50	181	61
14	University of Lisbon	Portugal	33	117	61
15	University of Newcastle	Australia	13	121	60
16	University of Alberta	Canada	27	134	59
17	Coventry University	England (UK)	18	154	58
18	Education University of Hong Kong	Hong Kong	29	93	58
19	Karolinska Institute	Sweden	30	175	56
20	University of Reading	England (UK)	10	132	56

The overlay map that emerged from the keyword co-occurrence analysis reveals the trend over the years, i.e., from 2015 to 2020, and gives an idea about research topics tendency (Goksu, 2021). The overlay visualization map related to our analysis is shown in Fig. 12. Analyzing Fig. 12, we notice that the search topics have almost not changed between 2015 and 2018 since there is a slight color variation. There is a change of research topics between 2017 and 2018, e.g., keywords like medical students, impact, attitudes, students, performance, technology, online, higher education, satisfaction, adoption, user acceptance, and success have been searched. However, it is remarkable that keywords like COVID-19, coronavirus, pandemic, and COVID-19 pandemic have stood out in recent years, i.e., between 2019 and 2020. These results suggest that COVID-19 impacts on e-learning, the reason why the researchers were interested in it between 2019 and 2020. Indeed, this is confirmed by the research of Chaturvedi et al. (2021), Ferrel and Ryan (2020), Marinoni et al. (2020), Dwivedi et al. (2020), and Schleicher (2020).

To explore the impacts of COVID-19 on the students' lives, Chaturvedi et al. (2021) carried out a survey of a total of 1182 people of various age groups from different educational institutions in Delhi, India. The authors' results revealed that COVID-19 has impacts on students' time spent on online courses and self-study, medium used for learning, students' sleep patterns, their daily fitness routine, and subsequent effects on their weight, their social life, and their mental health. With COVID-19's arrival, there is a need for medical researchers to study the pathology and health consequences

African contribution

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Fig. 12 Overlay visualization map of keywords according to year

published papers are South Africa (228 publications), Morocco (198 publications), Egypt (97 publications), Tunisia (88 publications), Algeria (67 publications), Nigeria (57 publications), Kenya (32 publications), and Ghana (21 publications). The most influential or cited countries are Morocco (cites: 368, TLS:10), South Africa (cites: 217, TLS:30), Egypt (cites: 166, TLS:14), Kenya (cites: 161, TLS:19), and Nigeria (cites: 79, TLS:21). We can state that South Africa, Morocco, and Egypt are the most influential countries by considering the number of publications, citations, and TLS value. We note the presence of Nigeria, and unfortunately the absence of Benin.

Among African universities that have researched on e-learning, the University of South Africa (48 publications), Abdelmalek Essaadi University from Morocco (23 publications), the University of KwaZulu-Nata from South Africa (23 publications), Mohammed V University from Morocco (19 publications), and Covenant University from Nigeria (23 publications) distinguishes themselves with the number of published articles. However, the most cited African universities with more than 5 publications are, Moi University from Kenya (cites: 146, TLS: 0), the University of South Africa (cites: 53, TLS: 3), Helwan university from Egypt (cites: 45, TLS: 0), Abdelmalek Essaadi University from Morocco (cites: 36, TLS: 0), and the University of KwaZulu-Nata from South Africa (cites: 32, TLS: 3). We can observe that the most influential universities come from South Africa and Morocco.

S. Bennani from Mohammed V University has published 11 papers, F. Assalimi from the University of Kairouan has published 11 papers, M. Jemni from the

University of Tunis has published 11 papers, K. Mansouri from Hassan II University of Casablanca has also published 11 papers, and L. Houghdir from Sidi Mohamed Ben Abdellah University has published 10 papers. The most African cited authors are J. K. Tarus from Moi University (cites: 149, TLS: 7), M. Erritali from Universit Sultan Moulay Slimane (cites: 146, TLS: 8), L. Houghdir from Sidi Mohamed Ben Abdellah University (cites: 28, TLS: 8), A. El Mhouthi from Abdelmalek Essaadi University (cites: 25, TLS: 0), and M. Erradi from Mohammed V University (cites: 25, TLS: 0). We note that the majority of the most influential authors come from North Africa or Maghreb countries. And we also note a total absence of authors coming from sub-Saharan Africa.

Discussions and conclusion

We performed the analysis on 12,272 publications on e-learning between 2015 and 2020, which represents 0.06466% of the research conducted between 2015 and 2020 on e-learning published in WoS, i.e., 12,272 of 18,976,811. We first performed a quantitative analysis of the metadata to determine the output by years, universities, countries, authors, journals, and research areas.

Countries such as Spain, the USA, England, China, and Romania produced more publications. By doing qualitative analysis, the most cited countries are the USA, followed by Spain, England, Australia, and China. A comparison of these results shows that although Romania is among the countries that have published more papers, it is not among the most influential countries (see Table 6). However, we found that Australia is among the top 5 most influential countries, but is not among the top 5 countries that have produced many papers (see Fig. 2).

The University Politehnica of Bucharest, the University of Hradec Kralove, the University of Hong Kong, King Abdulaziz University, and the Complutense University of Madrid are the universities with significant production (see Fig. 6). However, the University of Technology of Sydney, Islamic Azad University, the University of Malaya, Universidade Nova de Lisboa, and the University of Pittsburgh are the most cited universities (see Table 8). We notice that universities with more papers are not the most cited ones. Considering the TLS value, the influential universities are Islamic Azad University, Universidade Nova de Lisboa, and King Abdulaziz University.

Regarding the authors, C. Radu, M. Virvou, S. Lujan-Mora, C. Meinel, and I. Simonova are the authors with the most publications in the field. Unfortunately, they not the most cited; among those most cited, we have A. Tarhini, M. Aparicio, T. Oliveira, K. J. Tarus, and Z. Niu. It is not the number of publications from one country or university or author that makes it the most influential entity in the field. It is possible to produce enough documents, but if the documents are not relevant enough for the scientific community, it will be less cited, therefore less known and cited, consequently less influential. To be a reference in a research field, the quantity does not necessarily matter, but rather the quality of the work, especially the community that can read and evaluate the work. That is why it is necessary to find a journal recognized in the field to submit your work.

The most influential researchers in e-learning are generally those working in universities from the UK, the USA, and China. We noticed that the most cited authors do not write the most cited papers and do not come from the most influential countries or universities. This result shows that a research publication can be important in a field regardless of the author's origin or university or country. The second observation is that the collaboration between researchers working on e-learning is weak even though there are enough authors. The main collaborations are with developed countries like England, the USA, Spain, Italy, Germany, Australia, China, Netherlands, France, Canada, Portugal, and Belgium. Developing countries are currently lagging in educational technology, especially African countries.

The co-occurrence analysis highlights the importance of e-learning in education or higher education, and the relevance of using technology in education to enhance the student learning experience via collaboration tools and artificial intelligence. Reasons why journals like *Computers in Human Behavior*, *Computers & Education*, *International Journal of Emerging Technologies in Learning*, *BMC Medical Education*, and *British Journal of Educational Technology* are the most influential in e-learning in recent years. The co-occurrence analysis also revealed that very few researches deal with security or data protection in e-learning environments. When searching for security-related keywords in e-learning publications between 2015 and 2020, we got very few hits, for example, “academic integrity” (occurrence: 12, TLS: 44), “authentication” (occurrence: 15, TLS: 33), “confidence” (occurrence: 17, TLS: 42), “policy” (occurrence: 14, TLS: 53), “privacy” (occurrence: 18, TLS: 59), “risk” (occurrence: 51, TLS: 191), “risk management” (occurrence: 13, TLS: 33), “safety” (occurrence: 17, TLS: 88), and “security” (occurrence: 50, TLS: 132). These findings show that there is very little research on security in recent years.

Despite the absence of African countries on the worldwide level in the e-learning research area, African contribution analysis revealed the presence of South Africa, Kenya, and the majority of the Maghreb countries. We observed an absence of sub-Saharan countries, especially almost all francophone countries. The most influential universities and authors in Africa come from the Maghreb countries and South Africa. Despite the limited presence of African countries, the collaboration between these countries is very weak compared to their collaborations with developed countries. This can be explained by the fact that developed countries or influential countries offer their collaboration or funding to African countries. Efforts should be made among African countries to promote collaborative work in order to strengthen their position on the international scene.

This study has limitations. First, we only used WoS to collect the data, and it does not include all academic publications such as Scopus. Second, the latest publications (2020 publications) that were accepted but not indexed in WoS were ignored. Nevertheless, such limitations are unlikely to affect the results identified in this study. Furthermore, in the data search, we only used the term “e-learning” as search terms, while terms such as “online learning,” “distance learning,” and others can be used to extend the search scope. Although the use of synonymous search terms may lead to a more accurate dataset on the topic, the results obtained showed that our dataset retrieved from WoS is acceptable as all major aspects in e-learning are covered.

This study revealed that in recent years, research on security or data protection in e-learning has been relatively low compared to other research topics in the area. Is the security in e-learning not important? Are there security risks in e-learning environments? Or is learners' privacy not a concern? Our future work will be a literature review or an overview on data security in e-learning.

Acknowledgements This publication was made possible through the DSTN supported by IRD and AFD. We would like to thank the African Center of Excellence in Mathematical Science, Informatics, and Applications (CEA-SMIA) and the African Centre of Excellence on Technology Enhanced Learning (ACETEL) for their support.

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Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

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