A Bibliometric Analysis of the Scientific Production of e-Learning in Higher Education (1998-2020)

Yanjun Gao, Su Luan Wong, Mas Nida Md. Khambari and Nooreen Noordin

***Abstract*—Studies on E-learning in higher education have been gaining increasing attention from scholars in recent years. To have an overall understanding of these scientific productions of E-learning, a bibliometric analysis was done to conduct a quantitative scientific analysis of 1985 journal articles collected from the Scopus database. All the documents were analyzed through Biblioshiny and VOSviewer software. The results revealed that publications on E-learning increased at an exponential speed with a 26.48% annual growth rate. The *International Journal of Emerging Technologies in Learning* was the most productive while *Computer and Education* was considered the most impactful journal based on total citations. Europe and the United States played the leading role by publication quantity and total citations. At the researcher level, Al-samarraie, H. was ranked the top author in terms of both productivity and h-index, while Ebner, M. was the most influential author by total citations. The main themes drawn from the cluster analysis were "distance learning", "technology acceptance", "teachers' professional training and development" and "quality assessment of E-learning", which confirmed further previous research themes. The limitations of the study and recommendations for future research conclude the paper.**

***Index Terms*—E-learning, higher education, bibliometric analysis, trend development.**

I. Introduction

E-learning, which is defined as a virtual instruction mode, enables the use of content management systems to conduct instructional activities in a digital environment [1]. E-learning promotes both asynchronous and synchronous education delivery techniques by providing access to video conferencing, chat rooms, or online discussion boards [2].

This training model first appeared in 1996 with the introduction of information technology and the World Wide Web. It formed university consortiums to provide a digital educational option. Since then, this style of learning has grown in popularity [3], notably following the effects of COVID-19 on the education industry [4]. The benefits offered by E-learning contribute to more feasible dimensions of traditional teaching methods [5]. With the instructional materials and resources stored on its learning platforms, E-learning allows for the inclusion of numerous students without regard for space or time limits [6]. In addition, it provides better education opportunities for non-traditional learners who cannot attend classes in person, enabling them to continue their learning and complete their degree [7]. Apart from students, E-learning is beneficial for teachers as well, as it promotes faculty performance and productivity in addition to increasing access to educational resources [8]. Another advantage of E-learning is that it facilitates more communicative engagement between professors and students, as well as among peer students, through video conferencing, the discussion section of the learning platform, the learning community, and private communications [9]. For its accessibility, affordability, flexibility, and learning pedagogy, E-learning has become a prevalent delivery method [10].

E-learning has grown more technologically and operationally possible as information and communication technologies (ICT) have advanced. Higher education, as the most volatile area of external, internal, and time-driven changes, must frequently re-design learning processes to satisfy newly developed pedagogical, socio-cultural, or socio-economic demands [11]. In addition, financial restrictions, reduced infrastructure construction, and increased enrolment of non-traditional students have emerged as incentives for colleges to offer online programs [12]. Furthermore, due to the unexpected outbreak of COVID-19, higher education was obliged to shift all of its instructional operations to the distance education approach. In fact, even before the pandemic, a growing number of major universities had been beginning to offer courses and degrees through E-learning, which was becoming more recognized [13].

Currently, E-learning is increasingly seen as a long-term strategy of many higher education institutions that are the most significant catalysts of technological advancement [14]. Subsequently, more Internet-delivered courses and degree programs are offered by higher education institutions in response to the shifting mode of instructional delivery [15]. These institutions have adopted E-learning as part of their strategic planning process, since it has progressed from an experimental element to an existing institutional one [16]. As Mayadas *et al*. [17] stated, the learning mode is now established, growing, and here to stay.

With the growing popularity of E-learning, more undergraduate, graduate, and non-credit students are enrolled in distance courses [18], and a greater proportion of scholars have begun to place attention on this learning mode. Consequently, substantial research about this academic setting has been conducted over the last decades to shed light on the various conceptual and empirical perspectives of E-learning in higher education. Some specific viewpoints of previous studies include barriers and challenges in adopting an E-learning system [19], [20]; the factors behind the acceptance of an E-learning system [21], [22]; users' readiness and satisfaction with E-learning [23], [24]; the

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quality of online courses [25], [26]; and relevant E-learning systems or learning platforms [27].

Researchers have further conducted comprehensive systematic literature reviews on E-learning in higher education with different foci. For example, Kattoua *et al*. [28] presented a discussion of existing E-learning technologies, including their features, limits, benefits, and the primary variables influencing their acceptability. They subsequently determined that a good E-learning system should take personal, social, cultural, technological, organizational, and environmental elements into account [28]. Another research conducted by Bask *et al*. [29] established a conceptual framework drawn from an in-depth literature analysis of the important success criteria of E-learning deployment in higher education. The findings aided in the articulation of issues related to E-learning implementation in both formal and non-formal higher education, and therefore contributed to the creation of programs aimed to solve those relevant issues. More recently, Paiva *et al*. [30] identified the main keywords, theoretical frameworks, and research methodologies used in previous research amid the COVID-19 pandemic.

Previous literature reviews have provided different perspectives of E-learning in higher education. However, most extant reviews either involve a small-time range, a small number of studies, or a particular aspect of the E-learning field. There appears to be a lack of a large-scale exploration and discussion of scientific productions well-established in the higher education literature. Specifically, few studies have explored the issues, current development, and future trends based on the overall E-learning literature in a comprehensive way. Ergo, there is a need to expand and update the review research in response to the rapid growth of recent E-education publications. The present paper aims to fill this gap by introducing the full complexity of the literature on E-learning in higher education. In particular, a bibliometric analysis was conducted to analyze the existing literature to get an overall understanding of decades of E-learning research. In doing so, this study intended to present the importance and evolution of the concept of E-learning, specifically in higher education. With bibliometric analysis, the study ensured the quality and evaluation objectivity of the review via a systematic procedure. Based on the research gap discussed above and previous research, the following research questions were investigated:

RQ1: What are the annual distribution patterns of scientific publications on E-learning in higher education?

RQ2: Who are the main contributors in terms of articles, countries, authors, and journals in the E-learning field in higher education?

RQ3: What are the key research concepts and theme developments in the E-learning field in higher education?

II. Methodology and Materials

A. Research Design

Bibliometric analysis was done in this study to depict an overall picture of the existing knowledge on E-learning. Performance analysis, one of the main uses of bibliometric analysis, can evaluate the publication information of authors and institutions, such as the publications' annual distribution, citations, authors' ranks, countries, journals, and disciplines [31]. Additionally, science mapping, another main use of bibliometric analysis, develops structural images of scientific fields using bibliographic data [32]. Compared with the narrative literature review, which is likely to be affected by the researcher's subjective bias and is often less rigorous [33], bibliometric analysis can improve a review's quality and objectivity by introducing a systematic, transparent, and reproducible review process [32]. Given that the study focused on developing a comprehensive understanding of E-learning, it was appropriate to conduct a bibliometric analysis to look into the scientific productions of E-learning.

B. Data Collection

The second stage of the study involved the selection of an appropriate database for bibliometric analysis and the extraction of data from the selected database. The identification of the bibliographic database(s) is the first step, given its function as the main information source of scientific publications. One of the most important bibliographic databases created by publisher Elsevier in November 2004 is the Scopus database. It was selected for this study for the following three reasons: 1) As one of the most popular sources of bibliographic data by far, the Scopus database could provide a relatively broader coverage within a short time [34], which was more suitable for the present study's citation analysis; 2) the Scopus database contains data on all authors in cited references, which made it more accurate for the analysis of author-based citation and co-citation [32]; and 3) for this study's aim to collect extensive data on E-learning through bibliometric analysis, Scopus was aptly able to provide coverage of the topic, data type, and data extraction format.

Query words and Boolean operators were used to search for scientific documents in the field of E-learning. "E-learning" and "higher education" were selected as the keywords under study. The Boolean operator "AND" was used to combine keywords to procure a more accurate result. Therefore, the search equation was TITLE-ABS-KEY ("E-learning" AND "higher education").

The initial result from the search keywords and connectors generated 7460 publications. The search was not limited to a specific time period to cover as much literature as possible. However, publications from 2021 were excluded to conduct data analysis of a complete year, yielding 6820 publications.

All subject areas were included in the study because scientific publications on online education covered a multidisciplinary knowledge base and were not limited to a specific field. Therefore, it was necessary to include all subject areas for an extensive overview of online education in all fields.

In terms of the publications' document type and source type, only peer-reviewed journal articles were included, since papers are considered "certified knowledge" after a critical peer review process [35]. Consequently, a total of 4723 publications were excluded from the results. In terms of publication language, only articles published in the English language were selected. A total of 102 publications in other languages were then excluded at this stage.

Finally, 1995 journal articles were selected from the Scopus database. The search strategy is summarized in Table I.

TABLE I: DATA SEARCH STRATEGY

TYPE	CRITERIA
Database	Scopus
Search String	TITLE-ABS-KEY ("E-learning" AND "higher education")
Time Span	≤2020
Subject Area	All
Document Type	Article
Source of the publications	Journal
Language	English
Search Date	15/9/2021

After the documents were identified from the Scope database, the records of the 1995 documents were exported in CSV (comma-separated value) format with their authors' bibliographic information. Subsequently, the relevancy and eligibility of the articles were checked further. As a result, four publications with incomplete author information and six duplicate publications were excluded from the data selected for analysis. A final total of 1985 documents were therefore included in the bibliometric analysis. The process described above followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method [36] shown in Fig. 1.

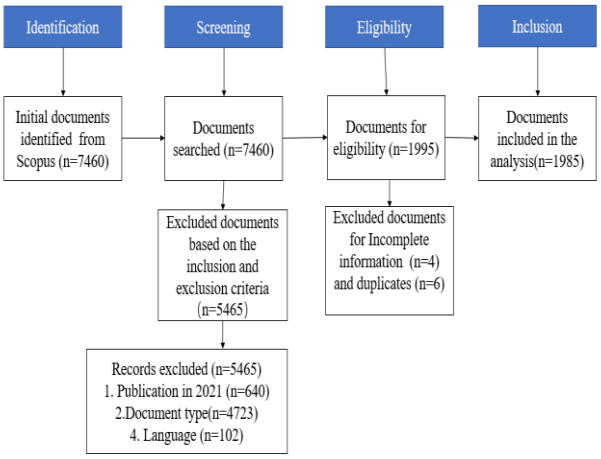

Fig. 1. PRISMA procedure for identifying documents.

C. Data Analysis

All analyses in the study were conducted using the Biblioshiny and VOSviewer software tools. Though both software can perform descriptive analysis and scientific production mapping, Biblioshiny was employed for descriptive analysis while VOSviewer was used to present network relationships for a better presentation effect.

Descriptive analysis of bibliometric data aims to highlight the basic characteristics of the scientific production of a certain knowledge field [34]. This phase's important elements include the selected publications' annual distribution patterns, productivity, impact, and most frequent keywords. Key concepts and themes are also presented based on keyword analysis, co-citation analysis, and cluster analysis at this stage.

III. FINDINGS AND DISCUSSION

The analysis results of annual publication trends with the number of papers published per year, contributions in terms of productivity, journal impact, countries, authors, and articles, and hotspots and themes are discussed in detail in this section.

A. Distribution and Development Trends

Descriptive analysis of the bibliometric dataset began with analyzing 1985 publications extracted from the Scopus database covering the period from 1998 to 2020. The development evolution of overall research trends is reflected by the annual distribution of documents [28]. From 1998 to 2020, despite a slight fluctuation in the publication pattern, the overall trend continued to increase exponentially with an annual growth rate of 26.48% (Fig. 2). In the early stage (1998 to 2002), the body of literature was quite small. For example, the highest number of publications per year was nine in 2002, with only one in 1998 and none in 1999. Research on E-learning was in its infancy at this point, showing that it did not catch most scholars' attention. This result confirmed the earlier discussion that the advent of E-learning was in the 1990s. From 2003 to 2009, the literature grew gradually, with an average of 42 publications per annum. During the high production period from 2010 to 2020, the number of documents exhibited sharp and stable growth with an annual publication count of 152, reaching its peak of 281 in 2020. Due to the availability and affordability of the Internet and technology, E-learning education grew rapidly from 2012. Following this, Internet-based E-learning obtained widespread attention. As expected, the number of publications on E-learning intensified swiftly amid the COVID-19 pandemic, during which face-to-face learning was not feasible.

B. Journal Contributions

A total of 644 journals were identified in this dataset. Of these, the top 10 journals were determined (as shown in Table II) according to the index of the most relevant journals. The most productive ones were the *International Journal of Emerging Technologies in Learning* with 92 articles, followed by *Computer and Education* and *Internet and Higher Education* with 90 and 56 articles respectively. The rest of the top 10 journals had published more than 20 journal articles each.

As the most common method to quantify the influence of an author, article, or journal, citation analysis is widely employed for its ability to easily detect significant research works in any field [29]. Therefore, the number of total citations was also used to assess the impact of a source on E-learning in this study (as shown in Table II). The top three sources by total citations were *Computer and Education* (9190), *Internet and Higher Education* (3835), *Computers and Human Behavior* (2262). Based on these results, it is important to note that some journals with fewer publications received higher citations and vice versa. For example, the *Journal of Computer Assisted Learning* acquired a total of 499 citations with nine publications and an average citation of 55. The *International Journal of Emerging Technologies in Learning*, with 92 articles, received 946 citations and an

average citation of 10. With the first publication in 2016, *IEEE Access* received a total of 572 citations from its 19 publications, with about 30 average citations.

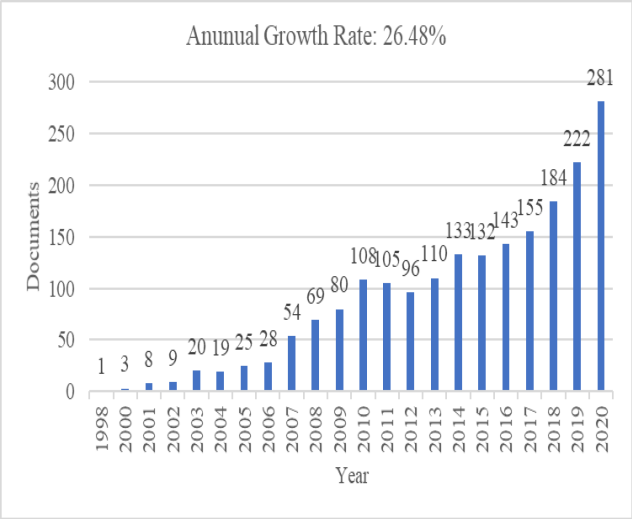

Fig. 2. The distribution trend of annual scientific productions.

TABLE II: MOST RELEVANT AND IMPACTFUL SOURCES

Source	NP	TC	PY_start
INTERNATIONAL JOURNAL OF EMERGING TECHNOLOGIES IN LEARNING	92	946	2009
COMPUTERS AND EDUCATION	90	9101	2007
INTERNET AND HIGHER EDUCATION	56	3835	2001
BRITISH JOURNAL OF EDUCATIONAL TECHNOLOGY	40	1493	2006
COMPUTERS IN HUMAN BEHAVIOR	37	2262	2007
INTERNATIONAL REVIEW OF RESEARCH IN OPEN AND DISTANCE LEARNING	35	591	2005
IEEE ACCESS	19	572	2016
IEEE TRANSACTIONS ON EDUCATION	15	435	2006
EDUCATIONAL TECHNOLOGY AND SOCIETY	10	770	2008
JOURNAL OF COMPUTER ASSISTED LEARNING	9	499	2002

NP: Number of Publications; TC: Total Citations; PY start: Staring year of publication

To assess source dynamics in E-learning, the journals' annual occurrences were analyzed, as shown in Fig. 3. A growing trend in each journal's publications was observed since the first paper published in 2001. Journals including the *Turkish Online Journal of Distance Education*, the *British Journal of Educational Technology, Internet and Higher Education*, and *Computer and Education* recorded slow but steady growth in their number of articles on E-learning. A more noticeable pattern of expansion was observed in the *International Journal of Emerging Technologies in Learning*, which exhibited exponential growth in its publications during the relatively short period from 2018 to 2020. It is expected that as an open source journal with regular issues, the *International Journal of Emerging Technologies in Learning* will still show a dramatic increase in papers on this subject in coming years.

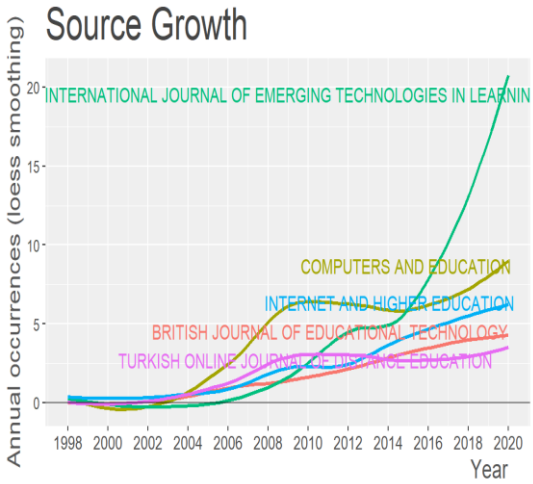

Fig. 3. Source dynamics by year of publication.

C. Country Contributions

The scientific production of one country in one field is an index to evaluate, to some extent, the influence of the country on that specific academic field [37]. A total of 98 countries or regions had published papers related to E-learning during the selected period. As seen in Fig. 4, the top five countries by publication number, in descending order, were Spain (575), the UK (527), the USA (490), Malaysia (309), and Australia (307). Evidently, Spain leads the way and plays a dominant role in the field. Malaysia was the only Asian country in the top five list; nonetheless, it is worth noting that four Asian countries (i.e., Malaysia, China, India, and Indonesia) were among the top 10 in scientific production. The development of academic research in the area shows that scholars are paying more attention to E-education, making this topic indispensable to the academic community.

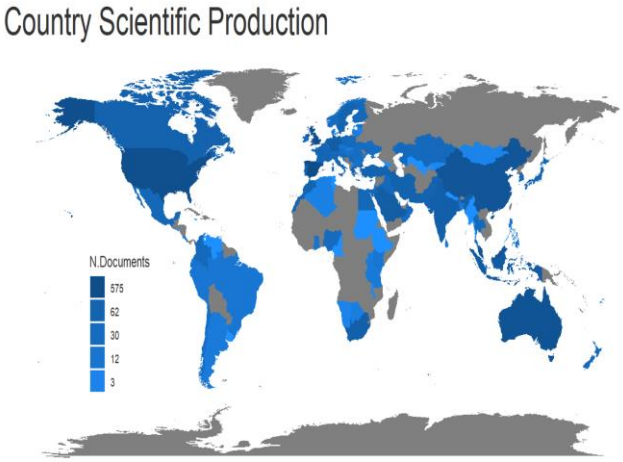

Fig. 4. Country scientific production distribution.

In terms of total citations, the countries and regions ranked top 10 were the USA, the UK, Australia, Spain, Malaysia, China, Canada, Hong Kong, Austria, and South Africa (see Fig. 5). The high citations distributed across these geographical spaces further confirm the high level of academic research on E-learning globally. Notably, Malaysia, China, and Hong Kong were Asian countries ranked in the top 10 by total citation.

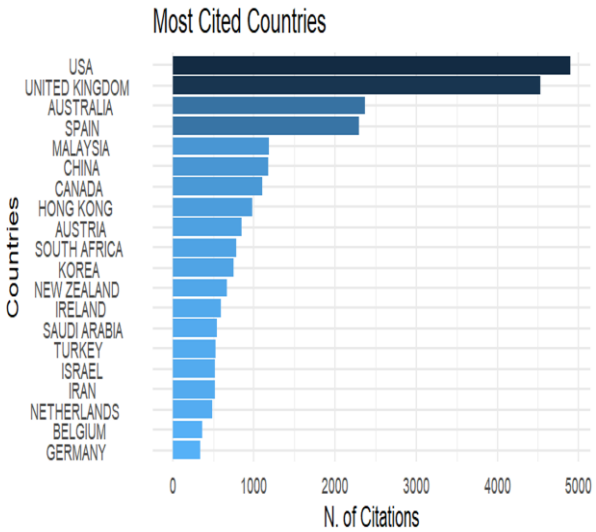

Fig. 5. Most cited countries.

D. *Most Influential Authors and Documents on e-Learning*

First, authors' productivity distribution was measured based on the frequency of articles published on E-learning. Al-samarraie, H. (7), Aristovnik, A. (6), Tsaic-w (6), and Umek, L. (6) were the top four out of 4895 authors in terms of their number of publications (see Table III). All authors had produced a minimum of five papers in the study field. To identify the most impactful authors, we assessed their h-index and performed citation analysis. The h-index of an author is based on the collection of articles most cited by researchers and the number of citations they have received in other journals [38], which indicates the impact of the author`s research [39]. For each of the 4895 authors listed in this analysis, we used Biblioshiny to measure individual research output by comparing papers published and citations obtained to determine each author's h-index ranking. The top 10 authors based on their h-index in the area of E-learning are shown in Table III. The top four authors were Al-samarraie, H., Aristovnik, A., Umek, L., and Al-Rahmi, W. M. with a h-index score of six, five, five, and five, respectively.

However, it is important to note that using only the h-index may result in the elimination of some significant writers who had fewer publications but were heavily referenced in the field. Given that the h-index calculates the cumulative influence of a researcher's output and citations, writers who published fewer articles but received higher citations may obtain a lower h-index score. To address this issue, citation analysis was done to identify the most impactful authors in the field. Citation analysis is commonly used to quantify the influence of an author, article, or journal because it enables significant research works in any field to be easily found [40]. The analysis showed that five out of the 4895 authors had received more than 400 citations for their work, as shown in Table III. Ebner, M. was the most cited author with a total of 823 citations for his four papers, making him the most influential referenced author in the E-learning literature. He is followed by Dawson, S., Macfadyen, L.P., Motivalla, L. F., and Rovai, A.P., who had 799, 736, 571, and 562 citations respectively. It is interesting to note that Motivalla's single paper had more citations than other authors' multiple papers combined.

TABLE III: MOST IMPACTFUL AUTHORS

Author	NP	Author	h_index	Author	TC
AL-SAMARRAIE H	7	AL-SAMARRAIE H	6	EBNER M	823
ARISTOVNIK A	6	ARISTOVNIK A	5	DAWSON S	799
TSAI C-W	6	UMEK L	5	MACFADYEN LP	736
UMEK L	6	AL-RAHMI WM	5	MOTIWALLA LF	571
ISSAT	5	EBNER M	4	ROVAI AP	562
AL-RAHMI WM	5	ZHU C	4	TESS PA	464
EBNER M	5	DAWSON S	4	CHAN YHC	458
KIM J	5	JUNG I	4	NGAI EWT	458
RAZZAQUE A	5	KHLAISANG J	4	POON JKL	458
ZHU C	5	MESEGUER-ARTOLA A	4	HOLZINGER A	455

TABLE IV: TOP10 MOST CITED ARTICLES

Main Author	Year	Title	TC
MOTIWALLA LF	2007	Mobile learning: A framework and evaluation	571
MACFADYEN LP	2010	Mining LMS data to develop an "early warning system" for educators: A proof of concept	567
TESS PA	2013	The role of social media in higher education classes (real and virtual) – A literature review	464
NGAI EWT	2007	Empirical examination of the adoption of WebCT using TAM	458
EVANS C	2008	The effectiveness of m-learning in the form of podcast revision lectures in higher education	438
EBNER M	2007	Successful implementation of user-centered game based learning in higher education: An example from civil engineering	429
GIKANDI JW	2011	Online formative assessment in higher education: A review of the literature	406
ROVAI AP	2002	Sense of community, perceived cognitive learning, and persistence in asynchronous learning networks	399
ALAVI M	2001	Research Commentary: Technology-Mediated Learning—A Call for Greater Depth and Breadth of Research	387
GOVINDASAMY T	2001	Successful implementation of e-Learning: Pedagogical considerations	376

The most influential journal articles related to E-learning were determined based on citation number. It was observed

that 71 out of 1985 articles had received a minimum of 100 citations; these papers can be thought of as key reference studies in the field of interest. With a total of 571 citations, the article titled "Mobile learning: A framework and evaluation" published in 2007 by Motivalla, L. F. [41] was found to be the most contributive article. The study explored the extension of E-learning into wireless computing devices with the help of a mobile learning framework. The high number of citations this paper has received since 2007 indicates its high quality and critical impact in the E-learning setting. The second-ranked article with 567 total citations was "Mining LMS data to develop an "early warning system" for educators: A proof of concept", published in 2010 by Macfadyen and Dawson [42]. The article developed a conceptual framework of an "early warning system" to predict students' final performance by tracking data from the learning management system. Tess's paper [43], with 464 citations, emerged as the third most impactful document in this field. The paper was a literature review that focused on the role of social media in a real or virtual setting in higher education. The top 10 most cited articles are shown in Table IV.

E. Key Concepts and Thematic Development

1) Key concept analysis

Keywords are high-level summarizations and refinements of the particle core [37]. The co-occurrence of keyword analysis is essential to determine the knowledge structures, research hotspots, and development trends of a specific domain [44]. In this part, the most frequent keywords were determined by the number of relevant wording occurrences, wherein the authors' keywords were the analysis unit. Statistical analysis of high-frequency keywords and their dynamic trend analysis were conducted via VOSviewer. Then, the themes of these publications were studied through cluster analysis with the aid of Biblioshiny and VOSviewer.

In this review, 4396 author keywords were determined from the analysis. The minimized co-occurrence number of keywords was set at 20, following which a total of 35 keywords with the highest frequency met the threshold (see Fig. 6). The map in Fig. 6 consists of circles and lines. Each circle represents a node, which indicates an author keyword on online education. The size of the circle reflects the frequency of the keywords' occurrence. The lines connecting the nodes represent the strength of the relationship between the keywords; the thicker the line, the stronger the relationship between the keywords. The distance between the nodes shows the similarity or relevance between two keywords.

From the macro perspective, the most frequent keywords in research articles on E-learning were "higher education", "online learning", "blended learning", distance learning", "mobile learning", "moodle", and "education". These keywords showed up in extensive studies in the E-learning literature.

From the micro perspective, "learning management system", "collaborative learning", "educational technology", "quality assessment", "social media", "Internet", "students", "design of online courses", and "technology acceptance" were the keywords most often used by scholars.

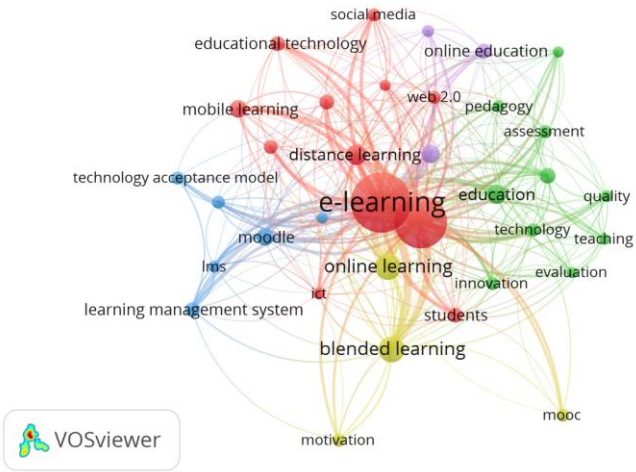

Fig. 6. Co-occurrence networks of high-frequency author keywords.

The annual dynamic trends of these author keywords were investigated with a minimum occurrence frequency of 20, as shown in Fig. 7. Based on the data, "Internet", "pedagogy", and "web 2.0" were the hot topics from 2008 to 2012, which constitute important infrastructure facilities of E-learning. Subsequently, specific E-learning topics such as "education technology", "instructional quality", "innovation", and "collaborative learning" received extensive attention from scholars between 2012 and 2016. Recently, "learning management system" and "moodle" were the hotspots discussed most often. It is interesting to observe that the usage of terms like "online learning", "blended learning", and "mobile learning" demonstrated increasing occurrences while "distance education" had a decreasing pattern. This is possibly because distance education has been studied in other new forms, such as E-education or virtual education. Online learning, in fact, is a "newer" and "improved" version of distance learning, according to Bozkurt *et al.*'s [44] research on trends in distance education.

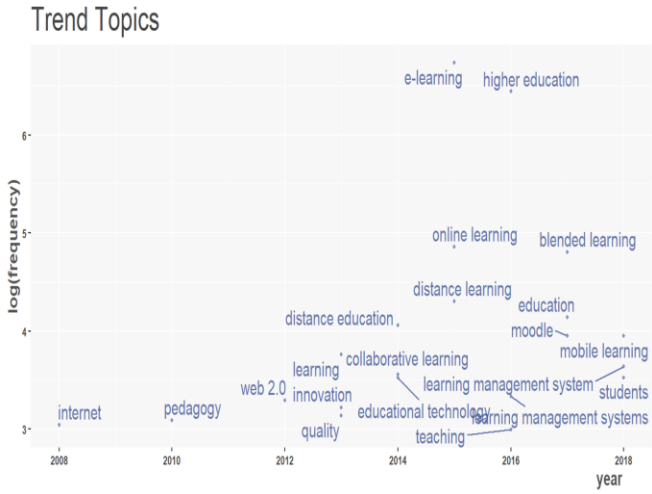

Fig. 7. Trends in author keywords.

2) Theme development

Cluster analysis, which is based on the frequency of keyword co-occurrence, employs statistical methods to simplify the complex relationships among keyword networks by forming subgroups [45]. In this study, the co-occurrence of author keywords was visualized to look into prevalent research themes. The threshold for keyword co-occurrence

was set at 15, following which 57 keywords out of 4396 were identified as visualization items (see Fig. 8).

In Fig. 8, the color of each node indicates an individual cluster to which the relevant keywords belong. Distinct clusters represent subcategories of research interest in the E-learning literature. The main themes are summarized in the following paragraphs.

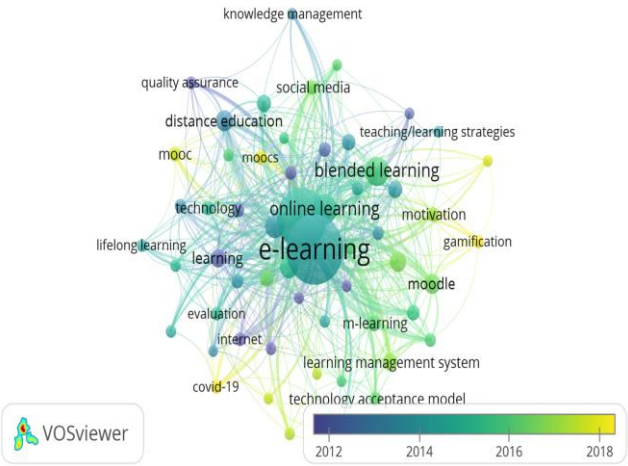

Fig. 8. Co-occurrence networks of author keywords.

Theme 1 mainly involves "distance education", which is related to "innovation", "instructional design", "lifelong learning", "mooc", "online education", "quality". Under this theme, research has focused more on distance learning than E-learning. Distance learning is different from traditional learning; therefore, the appropriate course design is critically important. As the main subjects of distance learning, non-traditional adult students appreciate a broad range of options for online courses in their E-learning. Additionally, students are more engaged in courses if different media are provided in various formats, such as images, audio, other technologies, or software [46]. Therefore, after first being introduced by Cormier in 2008, Massive Open Online Courses (MOOCs) drew significant attention. Supporters of MOOCs considered it to be biggest innovation in education in 200 years, while detractors see it as "taking a failed teaching model and putting it online" [47]. However, the effect and quality of MOOCs are worth noting. According to previous studies, issues related to MOOCs remain unresolved, including student retention in courses [48] and low completion of courses [49].

Theme 2 primarily pertains to the assessment aspect of E-learning in higher education, which is associated with "assessment", "E-learning", "evaluation", "virtual learning environment", "universities", "students", and "higher education institutions". Under this theme, evaluation or assessment takes on an important nuance. Assessment is an essential element in the higher education E-learning environment [50], where the absence of physical space or interaction poses challenges in assessing students' acquisition of knowledge and skills [51]. Therefore, the educational community needs to propose methods, strategies, and procedures to achieve effective and efficient evaluation processes [52].

Theme 3 centers on teachers' professional development, illustrated by keywords like "COVID-19", "distance learning", "Internet", and "teachers' professional development". High-quality faculty members play key roles in the successful implementation of E-learning in the higher education context. Due to the extensive impact of COVID-19 on education, higher education had to shift platforms abruptly and add contingency plans for future remote instruction in the post-pandemic period. Though researchers have argued for years that teachers and teacher educators should always be prepared for online and blended instruction [53], many teachers found themselves unprepared for the challenges of teaching completely online [54]. Luckily, professional development provides the training and guidance for teachers to successfully and quickly revise their courses to support online instruction.

Theme 4 focuses on the technology acceptance of E-learning, which is related to "adoption", "information and communication technology", "learning management", "moodle", "tam", and "technology acceptance". The benefits of E-learning systems are extensive; however, their level of utilization is considered to be less than satisfactory [55]. Researchers thus remain interested in exploring the influence of specific factors on E-learning adoption in various contexts, since factors vary from one research to the next depending on the participants and the situation. Thus, it is plausible that technology acceptance is a stable theme in E-learning research. It is also believed that there is a necessity for a comprehensive theoretical model to fully understand the factors affecting E-learning adoption under any circumstance, regardless of the context or individuals [56].

IV. Conclusion

The purpose of this bibliometric analysis was to analyze and assess scientific productions in the existing literature on E-learning in higher education. Publications were drawn from the Scopus database following the PRISMA procedure and examined quantitatively using the Biblioshiny and VOSviewer software.

The results show that the number of scientific documents on E-learning continues to rise exponentially and scholars from different fields have made great contributions to the area. The rankings of the publications differ based on different statistical indicators. In terms of journal contribution, the *International Journal of Emerging Technologies in Learning* was the most productive while *Computer and Education* was the most impactful journal based on total citations. With its first publication on E-learning in 2016, *IEEE Access* was ranked in the top 10 of both the most relevant journal list and the most impactful journal list. Notably, some journals revealed impactful roles in their specific field despite fewer publications. Productions based on geographical affiliation showed an uneven distribution throughout the world. Europe and the USA lead the way in E-learning research in terms of publication quantity. It is worth noting that the current emergence of some Asian countries (i.e., Malaysia, China, India, and Indonesia), as seen by their increasing publication rate, indicates the advent of their discourse power and voice expression in the academic community on online education. With regard to research power in the online teaching field,

European countries and the USA are still the most influential.

Productivity, h-index, and total citations were analyzed for a comprehensive understanding of the authors' contribution to E-learning. Al-samarraie, H. was ranked the top author based on productivity and h-index, while Ebner, M. was the most influential author by total citation number. The article titled "Mobile learning: A framework and evaluation" published in 2007 by Motivalla, L. F. [30] ranked first in article contribution.

The detailed analysis of author keywords uncovered existing and future development trends. "Online learning", "blended learning", distance learning", "mobile learning", and "moodle" were areas of interest for researchers. Themes were then drawn using cluster analysis to group high-frequency author keywords. "Distance learning", "technology acceptance", "teachers' professional development", and "quality assessment of E-learning" were the main themes in E-learning.

This study has contributed to the existing knowledge by using bibliometric analysis to empirically extend and complement previous studies on E-learning. The results offer important findings on the trends, contributors, and hotspots in the overall development of the E-learning educational community. While E-learning has advantages and disadvantages for both instructors and students, it has proven itself critical in maintaining the continuity of university teaching and research operations during an unforeseeable crisis like the COVID-19 pandemic. It is therefore imperative for universities to make strategic plans and take actions to build sustainable ways of E-learning for future implementation, particularly with relevant technologies and well-established infrastructure.

V. Limitations and Recommendations

Although much effort has been made to increase the validity of the bibliometric analysis findings, the limitations of this study have to be acknowledged. Only scientific publications from the Scopus database were analyzed in this study; ergo, care should be taken when generalizing the research findings to other contexts. In future research, other rich databases can be integrated to collect data and identify similarities and differences among research studies. Additionally, this study exclusively focused on journal articles published in English as the analysis unit, consequently excluding conference proceedings, doctoral dissertations, book reviews, textbooks, and books in other languages from the analysis. Future studies can seek to determine the proportion of these publications and document types. Finally, combining appropriate bibliometric analysis tools to extend text analysis will likely reveal additional information about the E-learning field.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

All authors contributed equally to this work. All authors wrote, reviewed, and commented on the manuscript. All authors have read and agreed to the published version of the manuscript.

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