sustainability

MDPI

Article

Towards a Sustainable Future: A Systematic Review of Mobile Learning and Studies in Higher Education

Md Asadullah [1], Minara Yeasmin [1], Abid Fakhre Alam [2], Abdulaziz Alsolami [3], Naved Ahmad [4,*] and Ibrahim Atoum [4]

[1] Department of Education, Aliah University, Kolkata 700160, India; asad.alig5@gmail.com (M.A.); minara.edu@gmail.com (M.Y.)
[2] Global Library, OP Jindal Global University, Sonipat 131001, India; abidf.alam@jgu.edu.in
[3] Department of Special Education, King Abdulaziz University, Jeddah 21589, Saudi Arabia; salsolmi@kau.edu.sa
[4] Department of Computer Science and Information Systems, Riyadh 13731, Saudi Arabia; iotoum@mcst.edu.sa
* Correspondence: nahmad@mcst.edu.sa

Abstract: In recent years, mobile learning has emerged as a promising educational paradigm, revolutionizing the landscape of higher education. As the world confronts escalating environmental challenges and calls for sustainable solutions, it becomes essential to explore the potential of mobile learning to contribute to a more sustainable future. This review encompasses a comprehensive analysis of the existing literature, focusing on empirical studies, theoretical frameworks, and case studies conducted between 2002 and 2021. A substantial corpus of 981 articles were selected for in-depth examination by employing rigorous inclusion and exclusion criteria. The findings reveal that mobile learning has witnessed significant growth and diversification within higher education, with pervasive adoption across various disciplines and student populations. The identified studies present many innovative mobile learning strategies, encompassing mobile applications, gamified learning platforms, augmented reality experiences, and location-based learning. In conclusion, this systematic review underscores the substantial potential of mobile learning in higher education toward a sustainable future. By harnessing technological innovations, promoting eco-friendly practices, and fostering digital inclusivity, institutions can embark on a transformative journey that enhances educational outcomes and contributes to environmental preservation and global sustainability efforts. Future research should focus on exploring new avenues for sustainable mobile learning and conducting longitudinal studies to assess the long-term impact of mobile learning initiatives on educational outcomes and environmental conservation.

Keywords: bibliometrics; mobile learning; higher education; mobility; robotics; coronavirus (COVID-19)

Citation: Asadullah, M.; Yeasmin, M.; Alam, A.F.; Alsolami, A.; Ahmad, N.; Atoum, I. Towards a Sustainable Future: A Systematic Review of Mobile Learning and Studies in Higher Education. *Sustainability* **2023**, *15*, 12847. https://doi.org/10.3390/su151712847

Academic Editor: Vasiliki Brinia

Received: 20 July 2023
Revised: 11 August 2023
Accepted: 14 August 2023
Published: 25 August 2023

1. Introduction

In the twenty-first century, mobile learning has become one of the most important tools for the advancement of higher education [1]. It is more interactive, necessitating more collaboration, communication, and engagement with others. In education and training, mobile learning is leading the way for new technologies to be integrated into modern educational and training systems [2].

Mobile learning has taken on a prominent part in higher education around the world in the robotic era [3]. It is a novel and distinct type of e-learning in which educational content is delivered only through a mobile technology device [4]. At this time, mobile devices are perfectly prepared for higher education. Furthermore, because this gadget is a highly personalized and collaborative communication tool, it allows students to expand their learning outside the classroom and into remote locations where computers are not available [5].

In the sphere of higher education, mobile technology plays the most crucial role in the learning process and instructional techniques [6]. Several studies emphasize the significance of technology in our media-rich environment, as well as the "learn anytime anywhere" mantra associated with mobile learning [7]. On a global scale, many groups, particularly instructors and students, use mobile phones to share knowledge and reference dictionaries and thesauri [8]. They have been portrayed as one of the applications for teaching and learning, with new opportunities for ICT use in higher education [9].

Today's educators can use mobile technologies to help them take a learner-centered approach to teaching and learning [10]. Students can learn in a variety of ways, including using mobile devices to access educational resources from a variety of sources, create their content, and connect with others to share resources both inside and outside the classroom [11]. M-learning is seen as the natural successor to e-learning by the majority of students, academics, and educators [12].

During the global (COVID-19) pandemic crisis, education ceased to function, and this had several consequences for the world's general progress [13]. The absolute closure of educational institutions as a result of COVID-19 has an influence not only on students but also on whole education systems around the world [14]. The closure of educational institutions obstructs face-to-face learning and forces us to consider alternatives to traditional classroom learning [15].

The mobile phone is playing an increasingly crucial part in the teaching–learning process during this pandemic [16]. To avoid student academic losses, most educational institutions began giving courses to students via online methods. Due to the lockdown, online classes or e-learning have become an important part of the teaching–learning process. Educational institutions, particularly higher education institutions, are now delivering their online classes via mobile devices in a wide range of ways to reach all students around the world [17]. Because of the increased use of mobile learning, a study to determine the efficiency of mobile learning during the COVID-19 pandemic [18].

Bibliometric analysis is the quantitative study of bibliographic material [19] and it provides a general picture of a research field that can be classified by authors, papers journals, and countries/regions [20]. Bibliometric methods use a quantitative procedure for describing, evaluating, and observing published research. From the WoS, we aimed to obtain meta-data of all the years of research on mobile learning in higher education. It is important to identify bibliometric maps by analyzing the mobile learning studies in the context of variables such as year of publications, authors, citations, journals, countries, keywords, and universities [21].

We found some previous research paper-related publications: Al-rahmi et al. (2021) from UTHM University of Malaysia, explored in his study the factors impacting mobile learning in higher education. The goal of the research was to investigate how Malaysian university students incorporate M-learning into their lessons. A questionnaire survey based on the technology acceptance model (TAM) was used to collect data, with 200 students from UTHM University of Malaysia participating [22]. Chattaraj and Vijayaraghavan, (2021) investigated the phenomena of multiple shifts in learning spaces caused by COVID-19 using the framework of mobility and space. The study was conducted in a Southern Indian University of more than 27,000 students. The implications of this work, according to the study, are extremely relevant and can considerably affect how pedagogues and researchers engage with various modes of learning—physical, online, and hybrid [23]. Goksu (2021) examined 5167 articles retrieved from the Web of Science database during 2015–2019, which constituted the scope of this study. The researcher used VOS viewer and sciMAT for bibliometric analysis. As a result of the bibliometric analysis, G. J. Hwang was the most influential researcher and the National Taiwan University of Science and Technology was the most influential university. The researcher also found that the most effective countries in mobile learning are Taiwan, the USA, China, and England [24]. Khan, Fm and Gupta, Y. (2021) undertook a bibliometric analysis of mobile learning in the education sector. The data were downloaded from the WoS database covering the period 2010 to 2020, a total number

of 722 articles studies, and were analyzed in VOS viewer software. The results found, through article co-citation analysis, that four clusters representing m-learning literature were identified [25]. Nassuora (2021) identified mobile learning for higher education in Saudi Arabia. A quantitative approach survey of 80 students was used by the researcher. The results of the statistical research suggest that students have a high level of acceptance for m-learning [26]. Park et al. (2011) investigated the factors affecting university students' adoption and use of mobile learning. A total of 288 Konkuk University students took part in the study. The study's findings validated the model's capacity to explain students' acceptance of mobile learning. The most essential construct in understanding the causal process in the model was m-learning AT, which was followed by students' MR and SN [27]. A study by Hung and Zhang (2012) was based on 119 academic publications published between 2003 and 2008. They reported that the number of m-learning papers climbed from 8 in 2003 to 36 in 2008 and that Effectiveness, Evaluation, and Personalized Systems was now the most popular domain [28]. One hundred and sixty-four mobile-learning studies spanning 2003 to 2010 were examined by Wu et al. (2012). Their key findings include that mobile learning system design comes second in most trials, with effectiveness coming first. The primary research methodologies were surveys and experiments [29]. To identify new trends in mobile learning research in higher education, Krull and Duart (2017) reviewed 233 articles published between 2011 and 2015. They noticed that the field of m-learning in higher education was expanding, as demonstrated by the widening range of research methodologies, themes, and researchers; the most popular research topic included the development of m-learning applications and systems [30].

Artificial Intelligence (AI) is revolutionizing mobile learning by embedding intelligence into educational apps and platforms, amplifying the effectiveness of learning experiences. Mobile-learning applications can capture and analyze user interactions, preferences, and performance metrics through AI-driven algorithms and data analysis. This enables the creation of personalized learning paths, where content is curated and delivered based on individual strengths, weaknesses, and learning styles.

Moreover, AI-powered mobile learning facilitates real-time assessment and feedback. Machine learning models can evaluate learners' responses and progress, providing immediate insights into comprehension and skill development. Furthermore, natural language processing capabilities enable chatbots or virtual assistants to engage in interactive conversations, answering questions and clarifying concepts, thus fostering a more immersive and self-directed learning experience. In essence, AI-infused mobile learning transforms education into a personalized, interactive, and efficient journey that adapts to the unique needs of each learner.

The term "sustainability" refers to the idea of addressing current needs without compromising the capacity of future generations to address their own needs. It encompasses three main pillars: environmental, social, and economic sustainability. Environmental sustainability focuses on preserving natural resources and ecosystems, reducing pollution and waste, and mitigating climate change. Social sustainability involves promoting equity, social justice, and well-being for all individuals and communities. Economic sustainability aims to create a stable and prosperous economy that provides opportunities for current and future generations. "Mobile learning" refers to the process of facilitating learning and education through the use of portable electronics like smartphones and tablets. Mobile learning can contribute to sustainability in several ways, aligning with the pillars of sustainability mentioned earlier:

Environmental Sustainability: Mobile learning reduces the need for printed materials, textbooks, and paper-based resources, conserving trees and reducing deforestation. Lower Energy Consumption: Compared to traditional classroom settings, mobile learning can consume less energy, significantly, when physical resources like transportation and infrastructure are minimized.

Social Sustainability: Mobile learning can be tailored to accommodate diverse learning styles, preferences, and needs, making education more inclusive for learners with disabili-

ties or different backgrounds. Mobile learning supports continuous learning throughout life, promoting personal and professional development and contributing to a more skilled and adaptable workforce.

Economic Sustainability: Mobile learning can reduce the costs associated with traditional classroom-based education, including transportation, infrastructure, and printed materials. It may analyze the impact of mobile learning on environmental, social, and economic dimensions, as well as highlight best practices, challenges, and potential areas for improvement. The study could provide insights into how institutions leverage mobile technology to enhance education while promoting a more sustainable future.

The author's best knowledge, along with some general insights about research gaps in the field of mobile learning and higher education studies, might help researchers understand the potential research gaps in this particular topic. The study might analyze the growth of research on mobile learning in the context of higher education over time. It could identify trends, publication patterns, and areas that have received more or less attention in the literature. An investigation into the methodological approaches used in mobile learning research within higher education could reveal trends in qualitative research methods, and quantitative ones using the PRISMA method. Identifying gaps in methodologies could help researchers design more robust studies. The study could explore the geographical distribution of research on mobile learning in higher education. It might uncover whether certain regions or countries have been more active in producing research in this area.

In addition to covering subject disciplines, this study critically evaluates the pedagogical strategies underpinning effective mobile learning. The study elucidates how educators harness mobile technologies to engage learners, promote active participation, and cultivate critical thinking skills by examining various instructional methodologies, such as collaborative learning, gamification, and personalized learning. Furthermore, the study meticulously examines the technological landscape, elucidating the gamut of tools and applications employed in mobile-learning contexts, from mobile apps and virtual reality platforms to social media integration. It probes the symbiotic relationship between technology and education, showcasing how synergistic integration can enhance information dissemination and create immersive, interactive learning environments. Moreover, the study dissects the tangible learning effects of mobile learning interventions, assessing their impact on cognitive development, knowledge retention, and skill acquisition. Synthesizing empirical evidence provides insights into how mobile learning can foster adaptive learning trajectories, accommodate diverse learning styles, and bridge accessibility gaps, thereby contributing to a more inclusive and influential higher education landscape.

This research aims to acquire a better understanding of mobile learning in higher education phenomena, especially in terms of its worldwide reach and cooperation. The latest data needs to be able to help researchers make recommendations for future research in the development of mobile learning in higher education. The present study is to use bibliometric techniques to review the literature on mobile learning in higher education. The objectives of the study are provided in the next section. The Section 3 contains a definition of the methodology. The results are then presented and discussed, and a conclusion is reached.

2. Objectives of the Study

The focus of the present study is on the following aspects of the scientific output in the area of mobile learning in higher education.

- To identify publication years over the past 20 years in the higher education system of the relevant literature;
- To examine the most productive author impact;
- To identify the most productive journal/source impact;
- To visualize co-citation-cited sources and cooccurrence keywords through VOS viewer software (Version 1.6.19);
- To visualize the interactions among the most productive authors, universities, and countries.

3. Data and Methodology

The Web of Science (Clarivate Analytics) database is the world's most comprehensive scientific citation search and analysis tool. ESI is a one-of-a-kind collection of performance statistics and trends based on the number of papers published in scholarly journals and the number of citations such publications received [31]. We analyzed the data retrieved from the Web of Science repository, which is one of the widely used databases for bibliometric analysis. In scientific research, it is critical to gain a broader perspective on existing research on a relevant subject matter, as well as a bibliometric analysis profile on the research trend line and the dynamics of research activities around the world. The study focused on the data of the Web of Science database due to the limited access to the other databases.

In order to investigate the new research fields for the post-COVID-19 policies for mobile learning in higher education, this study intends to provide prospective scholars with a conceptual framework by acknowledging earlier studies that have contributed to the development of new knowledge in the field. First, a thorough evaluation of the available literature on the subject at hand was performed for this aim. To ensure that only pertinent data were used in the study, rigorous criteria were afterward used to choose the final data. Researchers, practitioners, and policymakers may better comprehend management practices in the post-crisis era with sorted information.

The PRISMA method is a systematic review and meta-analysis method widely used in the health sciences. It identifies and evaluates research studies relevant to a particular research question or topic [32]. In the context of electronic medical records for mobile learning, a bibliometric analysis using the PRISMA method would involve a systematic search of relevant databases, such as WoS, to identify relevant articles once the articles had been identified, screened and evaluated for relevance, based on specific inclusion and exclusion criteria. The articles that met the criteria would then be reviewed in detail, and the data extracted and analyzed to answer the research question or objective. As depicted in Figure 1, we followed the PRISMA meta-analysis steps on EMR research, which includes four steps: (i) identification as recording identified through database searching, (ii) screening the record documents, (iii) eligibility records, and (iv) selecting studies.

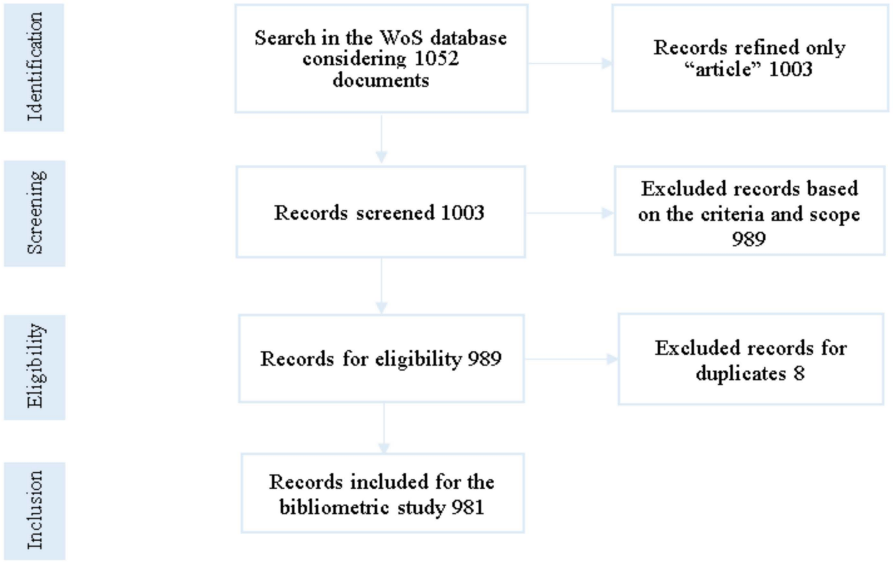

Figure 1. Detail flowchart illustrating the PRISMA meta-analysis steps on mobile learning research.

The data were extracted from 2002 to 2021. The study was conducted in October 2021, in which the search query was performed, extracting 1052 publications. The query used in the search engine of WoS was: "mobile learning" and "higher education" from a world perspective. The following ranks were obtained: year of publication, document type, research area, sources, and all keywords were all analyzed. Overall, we extracted 1052 documents,

of which 8 had duplicate information or related to unimportant issues; therefore, we removed them before conducting the final analysis. In the end, we had 981 documents from various sources (journals, books, conference papers, etc.). The present study also excluded books, journals, reports, conference papers, letters, notes, and reviews, with only 'articles' included. Details on the sample selection criteria we used for this investigation are shown in detail in Figure 2.

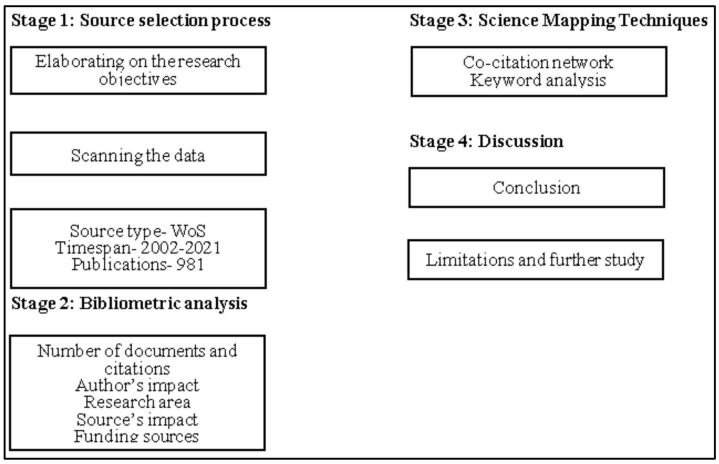

Figure 2. Flow of research design.

VOS viewer [33] was used to visually represent the co-citation-cited sources and cooccurrence keywords. The downloaded data were analyzed using R Studio [34] version 3.3.4 and MS Excel 2019 [35] to meet the objectives described above.

4. Results

4.1. Number of Documents and Citations by Year

Table 1 displays the annual mobile-learning-research publishing statistics from 2002 to 2021, indicating an upward trend in the number of publications. The British Educational Research Journal first published mobile learning research from Scopus indexed in 2002. From 2002 to 2021, the number of documents increased each year, but from 2003 to 2005 the number of articles published each year was the same, i.e., 3. In 2021, there was only one article, and it was promoted to 188 journals. However, although mobile learning is a relatively new topic, research on it has accelerated, and as a result, mobile learning has become popular among the academic research community, with most organizations starting research groups related to mobile learning and publishing their research studies.

Table 1. Number of mobile-learning publications in higher education research and citations by year on WoS database during 2002–2021.

Year	Records	% of Records	Cumulative	% of Cumulative	Citations	% of Citations
2002	1	0.10	--	--	0	0.00
2003	3	0.31	4	0.41	2	0.01
2004	3	0.31	7	0.71	2	0.01
2005	3	0.31	10	1.02	7	0.04
2006	5	0.51	15	1.53	13	0.07
2007	7	0.71	22	2.24	22	0.12
2008	9	0.92	31	3.16	74	0.39
2009	12	1.22	43	4.38	115	0.61
2010	13	1.33	56	5.71	213	1.14
2011	15	1.53	71	7.24	297	1.58
2012	22	2.24	93	9.48	380	2.03
2013	34	3.47	127	12.95	560	2.99

Table 1. *Cont.*

Year	Records	% of Records	Cumulative	% of Cumulative	Citations	% of Citations
2014	47	4.79	174	17.74	643	3.43
2015	53	5.40	227	23.14	918	4.90
2016	76	7.75	303	30.89	1213	6.47
2017	89	9.07	392	39.96	1628	8.69
2018	106	10.81	498	50.76	2130	11.36
2019	139	14.17	637	64.93	2976	15.88
2020	156	15.90	793	80.84	3751	20.01
2021	188	19.16	981	100.00	3799	20.27
Total	981	100.00			18,743	100.00

Figure 3 shows mobile learning publication and citation counts between 2002 and 2021. A total of 18,743 citations were received from 981 documents from 2003 to 2021. There were no citations received from 1 document in 2002. The highest citation was received in 2021 from 188 documents.

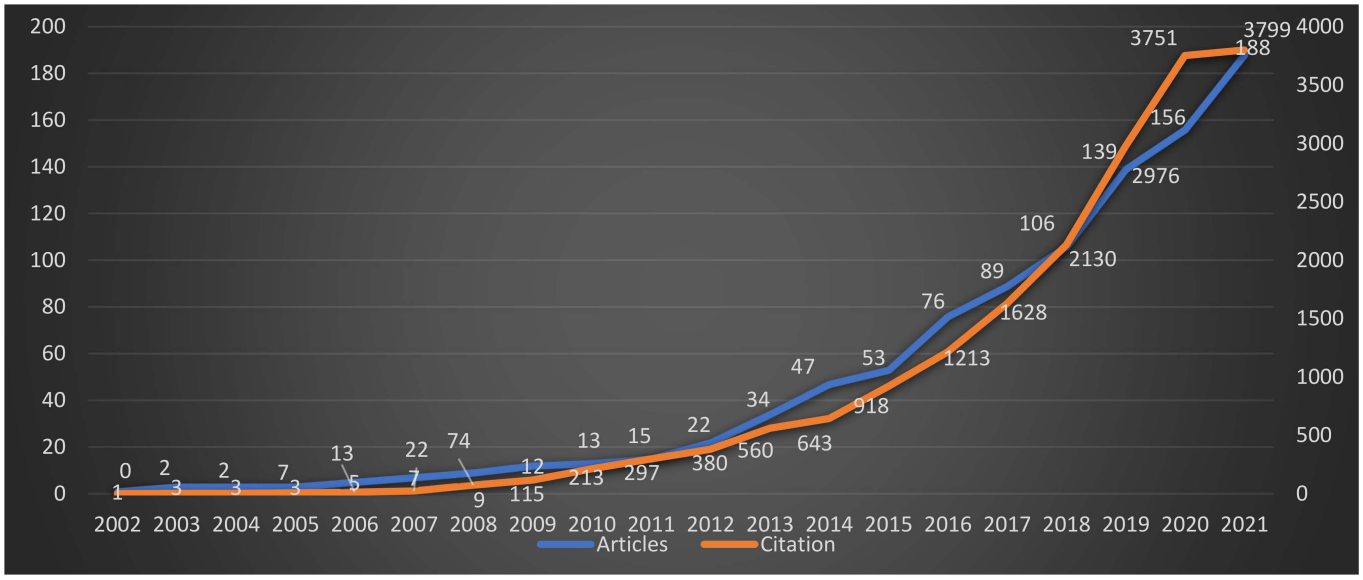

Figure 3. Number of mobile-learning research and citations by year.

4.2. Author Impact in Mobile Learning Research

Table 2 shows the most productive authors who contributed to research on mobile learning in higher education. A total of 981 documents were written by 2964 authors from 86 countries. The authors were ranked based on their total number of publications. A total of 10 of the 20 authors included in the table have published more than 5 publications. Hwang GJ takes the top rank with 16 papers; he received 769 citations, 11 H-index papers, and 16 G-index papers. Chiu DKW, Jong MSY, Lai Cl, Pimmer C, and Tsai CC were in second and third, fourth, five, and sixth place, respectively, with 6 papers. Lai Cl and Al-Emran M (the most productive authors are ranked 4 and 12) were the most highly influential authors among them all, with 228 and 227 citations in just 6 and 4 documents. Based on the h-index, Hwang GJ was at the top with the highest H-index of 11, which made him the most influential author, followed by Lai Cl. (2nd rank) and Tsai CC (3rd rank) with 6 H-index papers. Hwang GJ has the highest number of H-index papers (16). There were five authors who received 6 g-index papers, and these authors were ranked second.

Table 2. Author impact on mobile learning in higher education based on publications.

S. No.	Element	Records	h-Index	g-Index	Citations
1	Hwang GJ	16	11	16	769
2	Chiu DKW	6	3	6	70
3	Jong MSY	6	5	6	65
4	Lai Cl	6	6	6	228
5	Pimmer C	6	5	6	188
6	Tsai CC	6	6	6	180
7	Almaiah MA	5	5	5	99
8	Ho KKW	5	3	5	48
9	Huang YM	5	4	5	100
10	Lo P	5	3	5	69
11	Al-Adwan AS	4	3	4	67
12	Al-Emran M	4	4	4	227
13	Hernandez-Leo D	4	4	4	76
14	Kim H	4	3	4	60
15	Perez-Sanagustin M	4	4	4	50
16	Pinto M	4	3	4	26
17	Sales D	4	3	4	23
18	Shuib L	4	3	4	42
19	Vazquez-Cano E	4	3	4	124
20	Balakrishnan V	3	3	3	32

4.3. Top Productive Author Based on Citations on Mobile Learning

Table 3 shows the top productive author, those with a minimum of 50 citations per document on mobile learning in higher education. It depicts the major authors in the subject and how their ideas are related to one another. The author Hwang GJ received 183, 127, 95, 79, 70, and 55 citations from different sources. In the table, a number of three DOIs were not available among two authors, namely, Hwang GJ and Tsai CC. Interestingly, Hwang GJ was the author who received the most citations on the list of top nine authors. Al-Emran M had the highest received (28.333) citations per year in 2016, followed by Fu, QK and Hwang GJ, respectively. We found that based on the citation received by papers, Hwang GJ had the top citations received among the authors; he contributed five papers, as shown in Table 3.

Table 3. Top productive authors: those with a minimum of 50 citations per document on mobile learning in higher education.

S. No.	Author	Citations	Sources	Reference	Citation per Year	Year
1	Hwang, GJ	183	Educational Technology & Society	NA	22.875	2014
2	Al-Emran, M [36]	170	Computers in Human Behavior	10.1016/j.chb.2015.11.033	28.333	2016
3	Hsu, CK [37]	127	Computers & Education	10.1016/j.compedu.2012.12.004	14.111	2013
4	Pimmer, C [38]	118	Computers in Human Behavior	10.1016/j.chb.2016.05.057	19.667	2016
5	Fu, QK [39]	95	Computers & Education	10.1016/j.compedu.2018.01.004	23.75	2018
6	Chang, CY [40]	79	Computers & Education	10.1016/j.compedu.2017.09.001	19.75	2018
7	Hwang, GJ	70	Educational Technology & Society	NA	7	2012
8	Tsai, CC	70	Educational Technology & Society	NA	7	2012
9	Lai, CL [41]	55	Computers & Education	10.1016/j.compedu.2015.02.011	7.857	2015

4.4. Research Area of Mobile Learning

The documents were classified in this study based on their research areas, as shown in Figure 4. The data show that research on mobile learning in higher education has emerged in a variety of research areas. There were a total number of 981 publications on mobile learning studies between 2002 and 2021 during the study period, as shown in Figure 4. It can be seen that a maximum of 544 publications were published in the research area of Education Educational Research, followed by Computer Sciences with 192, Engineering with 89, Health Care Science Services with 55, and Psychology with 51. It is clear in the study that, "Education Educational Research" is the most popular research area within which to publish by mobile-learning researchers.

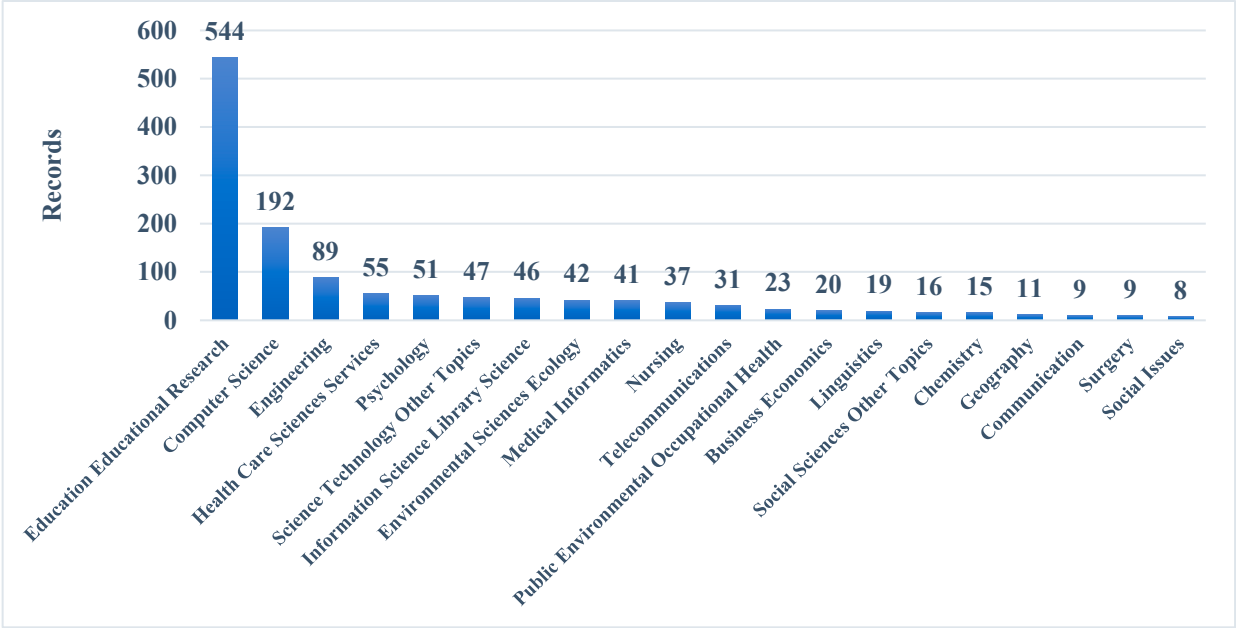

Figure 4. The research area of mobile-learning studies in higher education.

4.5. Sources of Mobile-Learning Studies

A total number of 981 publications on mobile learning in higher education from 2002 to 2021 appeared in different sources from different countries. The 262 journals preferred for mobile-learning publications for the period under study are listed in Table 4. Among the top 20 journals, Computers & Education had the highest research publication (58), received the most H-index (34) and G-index (58) ranks, and had a citation count of 4042; this was followed by Education and Information Technologies, which published 34 documents, and the British Journal of Educational Technology, which published 28 documents. The H-index ranking of the top sources/journals for mobile learning in higher education research identified the main journals to be Computers & Education, Computers in Human Behavior, the British Journal of Educational Technology, the International Review of Research in Open and Distributed Learning, and Educational Technology & Society.

4.6. Funding for Research on Mobile-Learning Studies

The science research fund is one of the most important global drivers of social, economic, and human development. The findings of scientific collaborations and subject distributions can help mobile-learning researchers in their search for research partners and funding. Figure 5 reveals funding for research on mobile learning from a world perspective during 2002–2021. Among the funding agencies, the Ministry of Science and Technology Taiwan gives the highest funding to researchers for research promotion.

Table 4. Sources of mobile learning studies in higher education based on publications.

S. No.	Sources	Records	h-Index	g-Index	Citations	* IF
1	Computers & Education	58	34	58	4042	2.556
2	Education and Information Technologies	34	11	15	303	3.95
3	British Journal of Educational Technology	32	13	22	545	2.951
4	Computers in Human Behavior	28	20	28	1201	6.829
5	Sustainability	25	7	11	152	3.251
6	Australasian Journal of Educational Technology	22	12	22	1003	1.171
7	International Review of Research in Open and Distributed Learning	21	13	21	747	2.297
8	Educational Technology & Society	19	13	19	797	2.086
9	Journal of Medical Internet Research	16	9	16	425	5.43
10	IEEE Access	15	9	12	161	3.367
11	Interactive Learning Environments	14	8	13	171	2.87
12	International Journal of Educational Technology in Higher Education	14	6	13	178	6.44
13	ETR & D-Educational Technology Research and Development	12	7	12	244	4.09
14	Journal of Computer Assisted Learning	12	8	12	468	3.862
15	International Journal of Engineering Education	11	5	9	102	1.29
16	Journal of Educational Computing Research	11	9	11	155	3.667
17	Telematics and Informatics	10	8	10	219	7.45
18	Anatomical Sciences Education	9	8	9	375	5.958
19	Nurse Education Today	9	5	9	104	3.442
20	Journal of Chemical Education	8	5	8	124	2.979

* IF—Impact Factor.

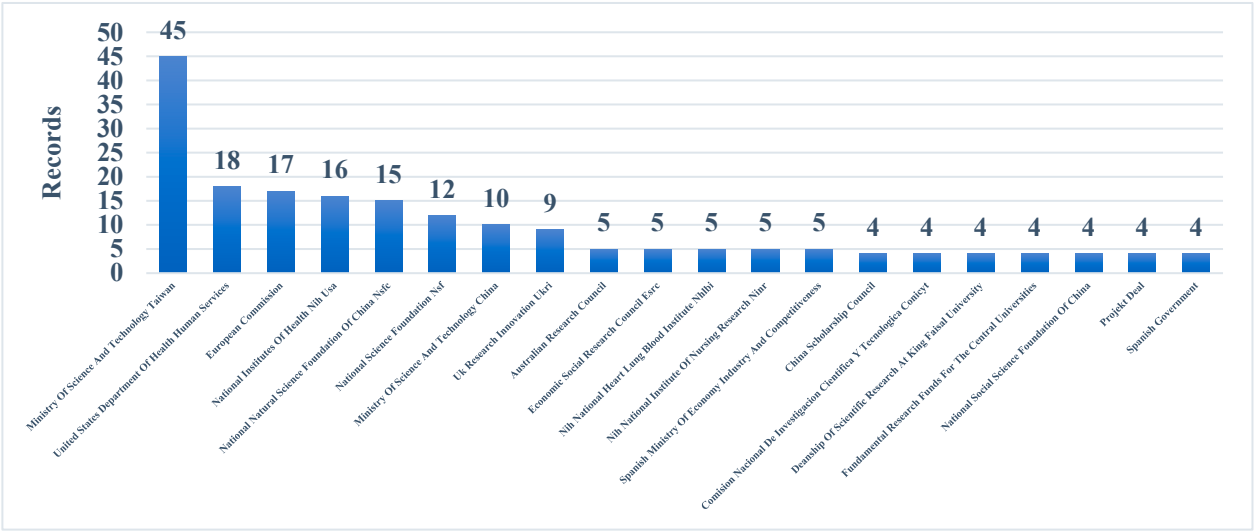

Figure 5. Funding for research on mobile-learning studies in higher education.

4.7. Co-Citation Network of Cited Sources on Mobile-Learning Research

Figure 6 represents the mapping of co-citations for cited sources of 20 citations on mobile learning in higher education. It demonstrates the key cited sources in the field and how their ideas were related to each other. A type of citation-network analysis method is co-citation analysis. It differs from the citation quantity analysis method, which is another citation analysis method. The citation quantity analysis approach uses the number of citations to assess the quality of the subjects (journal, author, country, document, etc.).

Figure 6 shows the cited sources of the co-citation network of mobile-learning research. The researchers created through VoS Viewer co-citation network map of cited sources; the result found 263 nodes with 190 links. The bigger nodes represent the more influential cited sources in this field. The four main clusters represent mobile-learning studies (Figure 6). The first cluster (Red) has 7 items, the second cluster (Green) has 5 items, the third cluster (Blue) has 5 items, and the fourth cluster (Yellow) has 3 items. The distance and thickness of the links represents the degree of cooperation between the cited sources. The largest linked component is shown in the network. As can be seen, Computer Education is the

largest node, indicating that this cited source is the most productive citation. The other prominent nodes with cited source names are the British Journal of Educational Technology and Computers in Human Behavior.

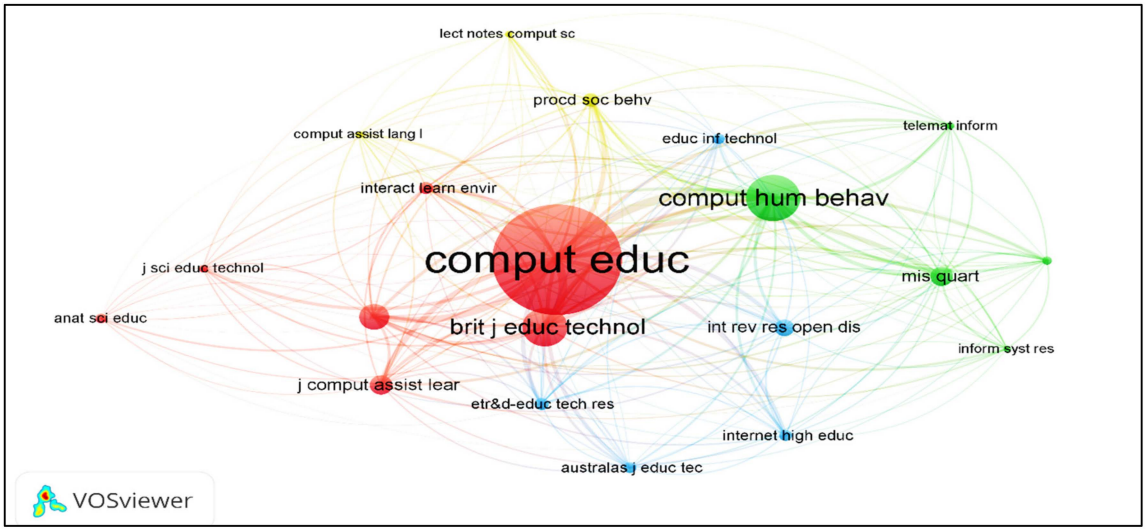

Figure 6. Co-citation network of cited sources on mobile learning research in higher education.

4.8. Co-Occurrence Keywords on Mobile-Learning Research

The VOS viewer software created the mobile-learning keyword co-occurrence network [42]. The keywords in the co-occurrence network map are the top 20 keywords in mobile-learning publications. The weights of the nodes are represented by the size of the nodes and words. The intensity of a relationship between two nodes is reflected in the distance between them.

Figure 7 indicates the most frequently used keywords in mobile-learning studies in higher education. After excluding the core keywords related to the search query from Web of Science, the data further revealed that mobile learning was the top keyword (n = 197), followed by higher education (n = 131), and education (n = 56). The VOS viewer software divided these 2563 keywords into four clusters with different colors on mobile learning studies.

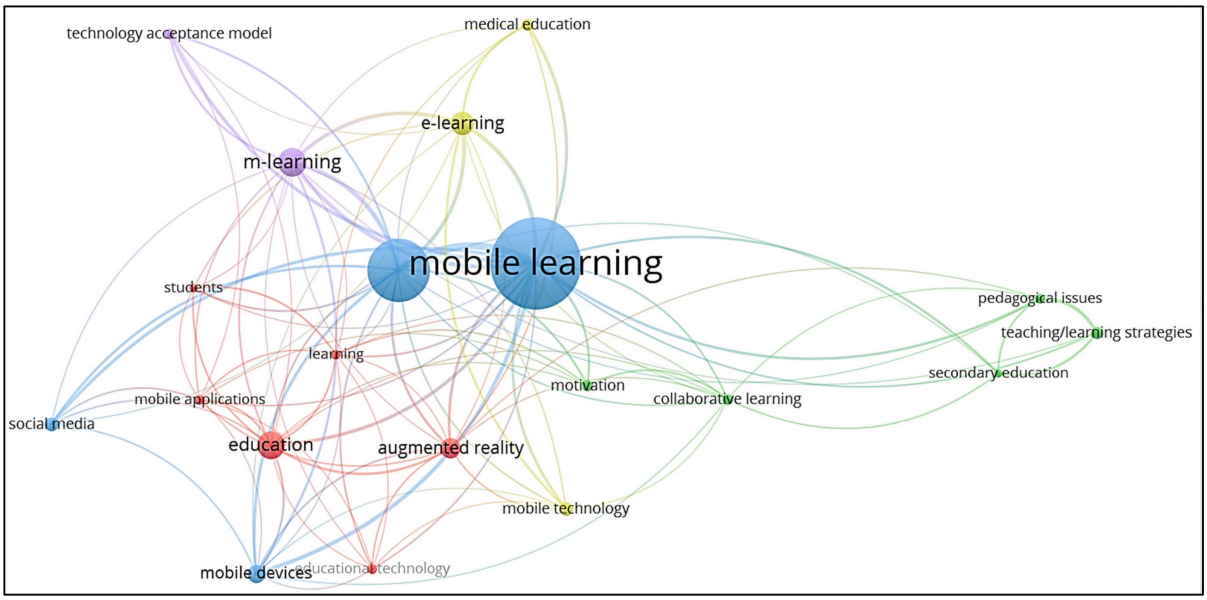

Figure 7. Co-occurrence keywords on mobile-learning studies in higher education.

- C1 (Red, six items): augmented reality, education, educational technology, learning, mobile applications, students;
- C2 (Green, five items): collaborative learning, motivation, pedagogical issues, secondary education, teaching-learning strategies;
- C3 (Blue, four items): higher education, mobile devices, mobile learning, social media;
- C4 (Yellow, three items): e-learning, medical education, mobile technology;
- C2 (Purple, two items): m-learning, technology acceptance model.

4.9. Three Fields on Mobile-Learning Research

A Sankey diagram (three-field) is a visualization used to illustrate the flow of values from one set to another. The things that are being connected are called nodes and the connections are called links. The Three Fields Plot from the Biblioshiny package was used to create relationships between the top authors, universities, and countries. The tool uses a Sankey diagram to depict the primary items of three specified fields (for example, authors, universities, and countries) and explain how they are related. In terms of network analysis, it was assumed that the networks would contain the widest possible variety of data. Figure 8 provides a three-field plot (Sankey diagram) listing the respective authors (left), universities (middle), and countries (right) in mobile-learning studies.

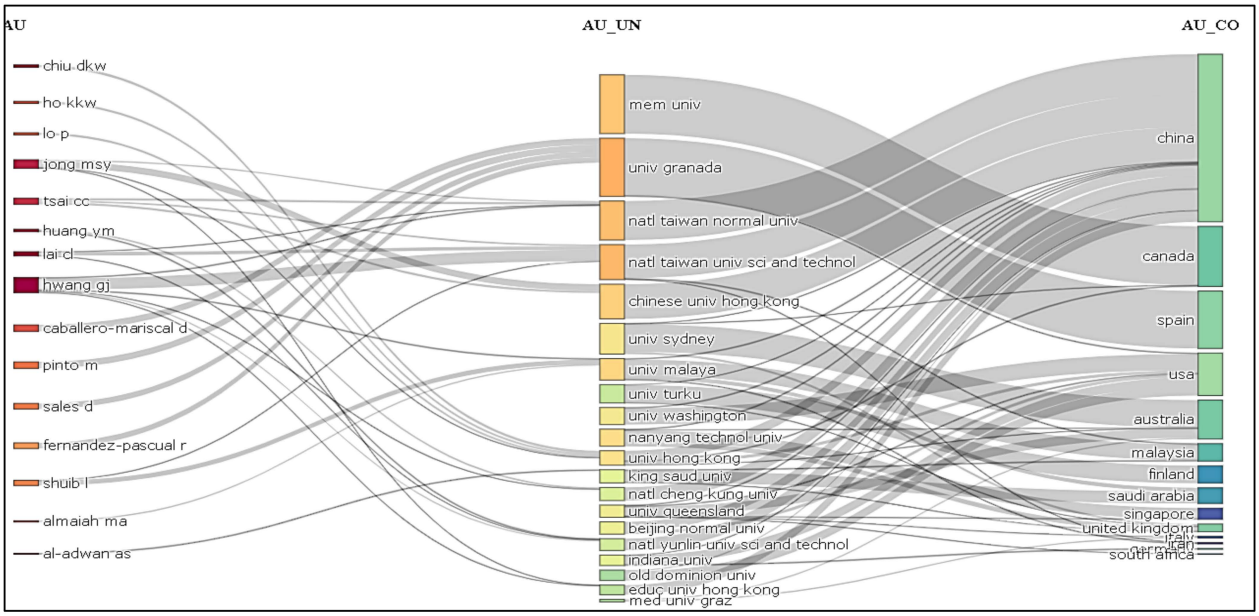

Figure 8. A three-field plot (Sankey diagram) was used to visualize the interactions among the most productive authors (**left**), universities (**middle**), and countries (**right**) on mobile learning studies from a global perspective.

Most of the papers that discussed consent were published in China, the USA, and Canada. The most productive university documents were published from Mem University, the University of Granada, and National Taiwan Normal University.

4.10. Analysis of Publications by Organization

Figure 9 shows the 50 organizations that have produced the most academic papers in this area of research. The top three organizations responsible for the publication of 55 out of 981 articles were the National Taiwan University of Science and Technology (24), the University of Granada (16), and the National Taiwan Normal University (15). The co-authorship network generated by the VOSviewer software (Figure 9) shows the prominent institutes that published articles on mobile learning and the cooperation between these institutions. The map in question was generated from this research sample of 981 articles. Figure 9 provides a VoS Viewer of visualization of the 50 organizations with the most

co-authorship. The threshold quantity of documents for the organization was set at three, and only 149 affiliations in 13 clusters matched the requirement. The size of the nodes in the diagram represents the quantity of documents, and the thickness of the edge in the figure represents the cooperation level.

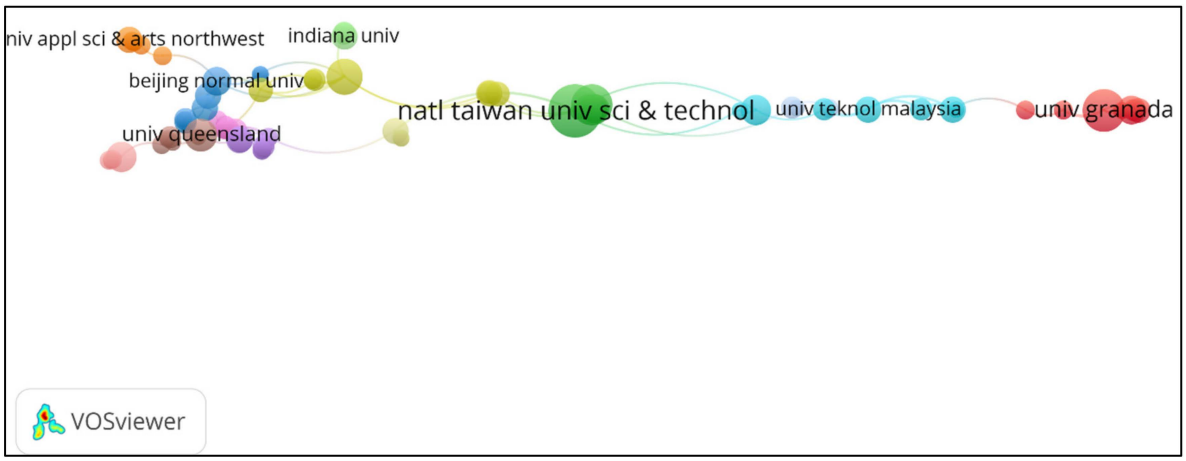

Figure 9. Analysis of publications by co-authorship organizations.

In the results shown in Figure 9, generated by the Web of Science, we found the National Taiwan University of Science and Technology, the University of Granada, and the National Taiwan Normal University.

4.11. Geographical Distribution by Country

The 981 publications that comprised the sample were spread out among 94 different countries, indicating, when the authors' countries of affiliation were examined that this study issue is international. This study indicates that each nation has at least one article published. Figure 10 shows the 50 countries that have produced the most academic papers in the area of research. According to the data, the USA had the highest number of publications, totaling 204 articles, followed by China with 105 articles, and Spain with 103 articles.

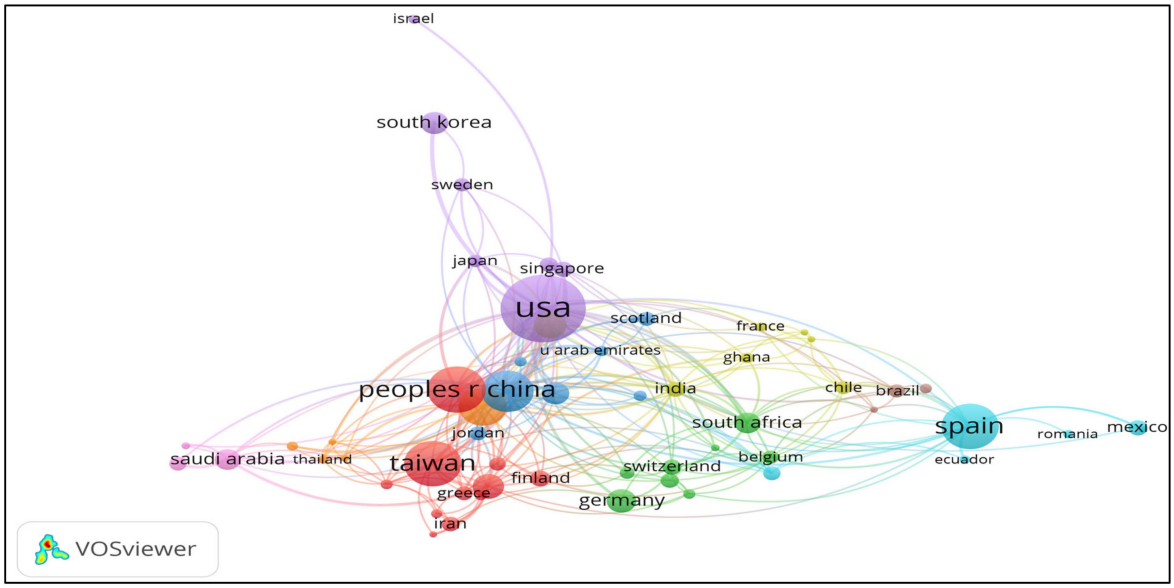

Figure 10. Geographical distribution by co-authorship country.

A network of 50 out of 94 countries presented a minimum of three documents. Any country with at least five citations in nine clusters was considered; only 58 countries met the set threshold, and were visually mapped using the VOS viewer, as shown in Figure 10. The co-authorship analysis of countries revealed the type and degree of collaboration in this subject and the relationship between the countries involved. Different colors are used to represent each cluster. The distance between the clusters on the map and the lines connecting them illustrate the strength of the relationships between authors from these countries and how frequently they publish as co-authors. This gives a decent picture of the strength of international collaboration in mobile-learning research.

5. Discussion and Conclusions

In this study, we conducted the analysis of mobile learning using R studio and VOS viewer to obtain a clear understanding of the development of mobile-learning studies in higher education over the last 20 years (2002–2021) from a global perspective. This study identified the major research focuses, the correlation between research areas, and the present status and developments in this topic by providing some clear and reasonable results.

The results obtained in this bibliometric study show that publication rates on this topic continue to increase. The growth of publications and citations increased every year from 2002 (1) to 2021 (188). There were 11 authors with a minimum of 50 citations per document on mobile-learning studies. Based on the number of articles in our analysis, the most productive researcher was determined by the number of citations. This study established G.J. Hwang as the most significant author in the area of mobile learning. H. Ogata (Showa University, Japan) was the most successful researcher in mobile learning, according to the findings of Bhardwaj and Jain (2015) [43].

Most of the papers that discussed consent were published in China, the USA, and Canada. The nation that made the most significant contribution to mobile learning was Taiwan. Taiwan's popularity in mobile-learning research is said to have been influenced by the Taiwanese government's e-learning program [44,45].

The journal of Computers & Education had the highest number of published articles (58), with the highest count of citations. The most common research area was Computers and Education and Computer Science. As can be seen (Table 4), the largest node was Computer Education, which showed that this cited source was the most productive. The British Journal of Educational Technology and Computers in Human Behavior are two other major nodes with cited sources.

These journals resemble those that [46] included in their study, which looked at the research on mobile learning. Accordingly, (Chee et al., 2017; Churiyah et al., 2022) discovered that Educational Technology & Society and the British Journal of Educational Technology are journals with regular studies on mobile learning [44,45]. The findings of our study are supported by the fact that Educational Technology & Society, the Journal of Computer Assisted Learning, and Computers & Education are among the top sources of mobile-learning studies, according to who looked at this research from 2003 to 2008.

Journals specializing in higher education, blended learning, and language learning were discovered to be among the most prominent journals, which was another outcome of this study. According to this study, the basic school level is followed by the higher education level in terms of the prevalence of mobile learning [29,44]. The findings of our study are supported by the discoveries of G.-J. Hwang and Wu (2014) and Arici et al. (2019) that mobile learning is primarily employed inside and outside the classroom [46,47].

This study identified and discussed the co-citation network in mobile learning, trending subjects, flourishing journals, publications, and researchers. In this way, it was intended to present a study that academics might use to inform future mobile-learning research and to reveal a bibliometric map of the mobile-learning field.

It is critical for policymakers, university administrators, and instructional designers to understand the influencing elements for mobile learning studies in higher education. To successfully adopt distance e-learning systems for higher education institutions, university

administrators should consider "effort expectancy" and "facilitating conditions" elements when giving institutional assistance to students. They should offer technical and financial assistance to students, such as mobile-learning literacy, ICT expertise, and data access. We hope that by publishing this paper, it will provide very useful insights into the trends in mobile technology publications. These findings can be used as a foundation for future studies and discussions in order to enrich and develop this field of study.

In conclusion, the study gives intriguing insights, as do other studies, but some factors constrain it. A multidisciplinary approach, for example, would call for a different set of keywords, like multidisciplinary. As a result, more profound research can be done in the future to examine this issue and increase the number of papers. Additionally, there are other opportunities for content analysis that highlights additional significant facets of the ongoing study issue of mobile learning in higher education.

Author Contributions: Conceptualization, M.A. and M.Y.; Methodology, A.F.A.; Software, A.A.; Writing—original draft, N.A.; Funding acquisition, I.A. All authors have read and agreed to the published version of the manuscript.

Funding: The authors would like to express their gratitude to AlMaarefa University, Riyadh, Saudi Arabia, for publication support.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

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

References

1. Szymkowiak, A.; Melović, B.; Dabić, M.; Jeganathan, K.; Kundi, G.S. Information technology and Gen Z: The role of teachers, the internet, and technology in the education of young people. *Technol. Soc.* **2021**, *65*, 101565. [CrossRef]
2. Ligi, B.; Raja, W.D. Mobile learning in higher education. *Int. J. Res. Granthaalayah.* **2017**, *5*, 2–7.
3. Elkhateeb, M.; Shehab, A.; El-bakry, H. Mobile Learning System for Egyptian Higher Education Using Agile-Based Approach. *Educ. Res. Int.* **2019**, *2019*, 7531980. [CrossRef]
4. Klimova, B.; Poulova, P. Mobile Learning in Higher Education. *Am. Sci. Publ.* **2016**, *5*, 5–10. [CrossRef]
5. Romero-Rodríguez, J.M.; Aznar-Díaz, I.; Hinojo-Lucena, F.J.; Cáceres-Reche, M.P. Models of good teaching practices for mobile learning in higher education. *Palgrave Commun.* **2020**, *6*, 80. [CrossRef]
6. Khalil-ur-rehman, F.; Raju, V.; Bekmyrza, T.; Farooq, M.; Kiani, F.S.; Khalil, N. Effects of Smartphone-Based Mobile Learning in Higher Education: A Systematic Review in the Context of Pakistan. *Int. J. Adv. Sci. Technol.* **2020**, *29*, 827–838.
7. Francisco, L.; Gabriel, M.; Marina, C.; Oliveira, M.D.; Manuel, C. A critical review of mobile learning integration in formal educational contexts. *Int. J. Educ. Technol. High. Educ.* **2018**, *15*, 2–15.
8. Walsh, C. The Right to Residency: Mobility, Tuition, and Public Higher Education Access. *Hist. Educ. Q.* **2021**, *61*, 297–319. [CrossRef]
9. Mohammadi, M.; Sarvestani, M.S.; Nouroozi, S. Mobile Phone Use in Education and Learning by Faculty Members of Technical-Engineering Groups: Concurrent Mixed Methods Design. *Front. Educ.* **2020**, *5*, 16. [CrossRef]
10. Ansori, Y.Z.; Santoso, E. Mobile Learning of Education Character based on Multicultural Value. *Al-Ishlah J. Pendidik.* **2021**, *13*, 1374–1382. [CrossRef]
11. Malchenko, S.; Tsarynnyk, M.; Poliarenko, V.; Berezovska-Savchuk, N.; Liu, S. Mobile technologies providing educational activity during classes. *J. Phys. Conf. Ser.* **2021**, *1946*, 012010. [CrossRef]
12. Díez-echavarría, L.; Valencia, A.; Cadavid, L. Mobile learning on higher educational institutions: How to encourage it? Simulation approach. *Univ. Natl. Colomb.* **2018**, *85*, 325–333. [CrossRef]
13. Burns, D.; Dagnall, N.; Holt, M.; Cooper, J.M. Assessing the Impact of the COVID-19 Pandemic on Student Wellbeing at Universities in the United Kingdom: A Conceptual Analysis. *Front. Educ.* **2020**, *5*, 582882. [CrossRef]
14. Kujur, S.; Murthy, G.R.K.; Indradevi, T.; Vinayagam, S.S. Learners' participation analysis in MOOCs during COVID-19. *J. Glob. Commun.* **2020**, *13*, 63–71. [CrossRef]
15. Al-Emran, M. Mobile learning dung the era of COVID-19. *Rev. Virtual. Univ. Católica. Del. Norte.* **2020**, *61*, 1–2.
16. Asghar, M.Z.; Barber, Ã.E.; Younas, I. Mobile learning technology readiness and acceptance among pre-service teachers in Pakistan during the COVID-19 pandemic. *Knowl. Manag. E-Learn. An. Int. J.* **2021**, *13*, 83–101.

17. Raja, M.A.S.; Kallarakal, T.K. "COVID-19 and students perception about MOOCs" a case of Indian higher educational institutions. *Interact. Technol. Smart. Educ.* **2020**, *17*, 450–477.
18. Grześkowiak, M.; Chudzicka-Strugała, I.; Zwoździak, B.; Swora-Cwynar, E.; Nijakowski, K.; Jokiel, M.; Roszak, M. E-learning during the Coronavirus pandemic–creating educational resources for teaching medical students. *Stud. Log. Gramm. Rhetor.* **2020**, *64*, 77–97. [CrossRef]
19. Hossain, S.; Batcha, M.S. A Scientometric Analysis and Visualization on Beta Thalassemia Research at Global Perspectives. *J. Hosp. Libra.* **2021**, *21*, 391–404. [CrossRef]
20. Baskaran, C. Research productivity of Alagappa University during 1999–2011: A bibliometric study. *DESIDOC J. Libr. Inf. Technol.* **2013**, *33*, 236–242. [CrossRef]
21. Kumar, V.M.; Das, S.; Kumar, Y.S. Research Productivity of Mizoram University, Aizawl During 2002-2018: A Bibliometric Analysis. *J. Indian Libr. Assoc.* **2020**, *56*, 1–11.
22. Al-rahmi, A.M.; Al-rahmi, W.M.; Alturki, U.; Aldraiweesh, A. Exploring the Factors Affecting Mobile Learning for Sustainability in Higher Education. *Sustainability* **2021**, *13*, 7893. [CrossRef]
23. Chattaraj, D.; Vijayaraghavan, A.P. The mobility paradigm in higher education: A phenomenological study on the shift in learning space. *Smart Learn. Environ.* **2021**, *8*, 15. [CrossRef]
24. Goksu, I. Bibliometric mapping of mobile learning. *Telemat. Inform.* **2021**, *56*, 101491. [CrossRef]
25. Khan, F.M. A bibliometric analysis of mobile learning in the education sector. *Interact Technol. Smart Educ.* **2021**, *19*, 338–359. [CrossRef]
26. Nassuora, A.B. Students Acceptance of Mobile Learning for Higher Education in Saudi Arabia. *Int. J. Learn. Manag. Syst.* **2021**, *9*, 24–30. [CrossRef]
27. Park, S.Y.; Nam, M.; Cha, S. University students' behavioral intention to use mobile learning: Evaluating the technology acceptance model. *Br. J. Educ. Technol.* **2011**, *43*, 592–605. [CrossRef]
28. Hung, J.L.; Zhang, K. Examining mobile learning trends 2003–2008: A categorical meta-trend analysis using text mining techniques. *J. Comput. High. Educ.* **2012**, *24*, 1–17. [CrossRef]
29. Wu, W.H.; Wu, Y.-C.J.; Chen, C.-Y.; Kao, H.-Y.; Lin, C.-H.; Huang, S.-H. Review of trends from mobile learning studies: A meta-analysis. *Comput. Educ.* **2012**, *59*, 817–827. [CrossRef]
30. Krull, G.; Duart, J.M. Research trends in mobile learning in higher education: A systematic review of articles (2011–2015). *Int. Rev. Res. Open Distrib. Learn.* **2017**, *18*, 1–22. [CrossRef]
31. Hossain, S.; Batcha, M.S.; Atoum, I.; Ahmad, N.; Al-Shehri, A. Bibliometric Analysis of the Scientific Research on Sustainability in the Impact of Social Media on Higher Education during the COVID-19 Pandemic. *Sustainability* **2022**, *14*, 16388. [CrossRef]
32. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Int. J. Surg.* **2021**, *88*, 105906. [CrossRef]
33. Almulhim, A.I.; Aqil, M.; Ahmad, S.; Abdel-magid, I.M. Sustainable water planning and management research in Saudi Arabia: A data-driven bibliometric analysis. *Saudi Soc. Geosci.* **2021**, *14*, 1950. [CrossRef]
34. Ashiq, M.; Rehman, S.U.; Muneeb, D.; Ahmad, S. Global research on library service quality: A bibliometric analysis and knowledge mapping. *Glob. Knowl. Mem. Commun.* **2021**, *71*, 253–273. [CrossRef]
35. Hossain, S.; Batcha, M.S. Scientometric analysis of research productivity from Indian dialysis over the last twenty years in Web of Science. *Collnet J. Sci. Inf. Manag.* **2021**, *15*, 323–339. [CrossRef]
36. Al-Emran, M.; Elsherif, H.M.; Shaalan, K. Investigating attitudes towards the use of mobile learning in higher education. *Comp. Hum. Beh.* **2016**, *56*, 93–102. [CrossRef]
37. Hsu, C.-K.; Hwang, G.-J.; Chang, C.-K. A personalized recommendation-based mobile learning approach to improving the reading performance of EFL students. *Comp. Educ.* **2013**, *63*, 327–336. [CrossRef]
38. Pimmer, C.; Mateescu, M.; Gröhbiel, U. Mobile and ubiquitous learning in higher education settings. A systematic review of empirical studies. *Comput. Hum. Behav.* **2016**, *63*, 490–501. [CrossRef]
39. Fu, Q.-K.; Hwang, G.-J. Trends in mobile technology-supported collaborative learning: A systematic review of journal publications from 2007 to 2016. *Comp. Educ.* **2018**, *119*, 129–143. [CrossRef]
40. Chang, C.-Y.; Lai, C.-L.; Hwang, G.-J. Trends and research issues of mobile learning studies in nursing education: A review of academic publications from 1971 to 2016. *Comp. Educ.* **2018**, *116*, 28–48. [CrossRef]
41. Lai, C.-L.; Hwang, G.-J. An interactive peer-assessment criteria development approach to improving students' art design performance using handheld devices. *Comp. Educ.* **2015**, *85*, 149–159. [CrossRef]
42. Bhardwaj, R.K.; Jain, P.K. Research trends in mobile learning: A global perspective. *Collnet J. Sci. Inf. Manag.* **2015**, *9*, 205–224. [CrossRef]
43. Hwang, G.; Tsai, C. Research trends in mobile and ubiquitous learning: A review of publications in selected journals from 2001 to 2010. *Br. J. Educ. Technol.* **2011**, *42*, 65–70. [CrossRef]
44. Chee, K.N.; Yahaya, N.; Ibrahim, N.H.; Hasan, M.N. Review of mobile learning trends 2010–2015: A meta-analysis. *J. Educ. Technol. Soc.* **2017**, *20*, 113–126.
45. Churiyah, M.; Sholikhan, S.; Filianti, F. Mobile learning uses in vocational high school: A bibliometric analysis. *World J. Educ. Technol. Curr. Issues* **2022**, *14*, 484–497. [CrossRef]

46. Hwang, G.-J.; Wu, P.-H. Applications, impacts and trends of mobile technology-enhanced learning: A review of 2008–2012 publications in selected SSCI journals. *Int. J. Mob. Learn. Organ.* **2014**, *8*, 83–95. [CrossRef]
47. Arici, F.; Yildirim, P.; Caliklar, Ş.; Yilmaz, R.M. Research trends in the use of augmented reality in science education: Content and bibliometric mapping analysis. *Comput. Educ.* **2019**, *142*, 103647. [CrossRef]