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Review Article

An examination of mobile learning adoption in higher education: Research trends in twenty years

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ABSTRACT

Mobile learning presents many benefits to lecturers, students, and universities. It provides the opportunity for all to access information anytime and anywhere and also promotes learning autonomy and mobility. This paper aims to systematically analyze publications on mobile learning in higher education conducted over twenty years by providing knowledge to help researchers in this area. The data were obtained from the Scopus database. A total of 587 peer-reviewed publications were analyzed. The results show that the number of articles increased significantly after 2016, and there was an upward trend after 2018. Our results regarding prolific journals show that many articles in this field were published in several prominent journals. Our results revealed that 91 countries contributed to research worldwide, and the most productive institutions are from different continents. In addition, results indicated that recently published countries on the topic are India, Saudi Arabia, Thailand, Indonesia, and Germany. Regarding research trends, our results yielded three research clusters. The first cluster focused on building a learning environment for students, while the second cluster included research on mobile learning in medical education. In addition, the third cluster investigated young adults' use and perceptions of mobile phones in learning through surveys and questionnaires. Moreover, the results we obtained demonstrated that recent studies also focused on academic performance and augmented reality was a trending topic before academic performance.

Keywords: mobile learning adoption, mobile learning, higher education, m-learning, research trends

INTRODUCTION

The swift advancement of technology and its widespread accessibility across all age groups has necessitated integrating mobile learning into education. In the past decade, with mobile tools' development, online learning environments and digital tools have become important in education (Damilola & Oluwalani, 2013; Lin et al., 2023; Oyelere et al., 2017). In parallel with this development, mobile learning, also known as m-learning, has become an emerging technology increasingly integrated into educational settings (Damilola & Oluwalani, 2013; Valencia-Arias et al., 2024). In general, mobile learning is commonly defined as the process of learning that utilizes the internet and mobile devices like cell phones, tablets, and laptops (Oyelere et al., 2017; Pramana, 2018). It mainly aims to conduct instruction using electronic devices, regardless of physical location or time constraints, to facilitate students' acquisition of course content using mobile devices and offer prompt feedback on their learning progress (Parsons et al., 2023; Suartama et al., 2019). In the era of digitization for the last decade, mobile learning devices, such as cell phones and tablets, have evolved from being a mere preference to an essential requirement and have become an essential part of daily life for nearly everyone (Lin et al., 2016).

Researchers have indicated that mobile learning has presented many benefits to student's academic achievements and enhances their affective factors such as attitudes, interests, and motivation (El-Sofany & El-Haggar, 2020; Kang, 2024; Li & Li, 2024). Moreover, the potential of mobile learning to encourage students by visualizing and auditory stimuli may enhance the appeal of learning and foster students' interests (Ibrahim, 2024; Yin et al., 2019). For example, mobile learning devices have evolved beyond their original purpose of communication and are now pervasive in all aspects of life (Lin et al., 2023; Zhang, 2022). This kind of instruction helps students and teachers present an opportunity for an online learning environment outside the classroom (Parsons et al., 2023). In addition to students, this opportunity allows lecturers to communicate with students online, assign and provide feedback on assignments, and engage with the mobile learning application. Thus, mobile learning aims for students to acquire knowledge related to course subjects or queries from mobile devices using learning content and activities in developed mobile learning applications (El-Sofany & El-Haggar, 2020).

Research has indicated that mobile learning has been proposed as an effective strategy for incorporating technology into formal education (Elfeky & Masadeh, 2016; Kang, 2024). Also, researchers have revealed the advantages and benefits of mobile learning in terms of accessing information and ensuring its availability for immediate use by students (Huang et al., 2020). Moreover, promoting student autonomy by enabling active participation in the learning process has been among the advantages and benefits of mobile learning (Kang, 2024). From this perspective, learners can conveniently access course content and acquire knowledge and understanding of concepts and topics at their preferred speed in the mobile learning environment. In addition, lecturers and teachers can engage students in mobile learning and customize course content to suit their specific requirements to enhance students' achievement and increase interest and motivation to learn (Badawood & AlBadri, 2021).

Mobile learning has gained considerable attention in recent years in research in higher education (Naveed et al., 2023; Pimmer et al., 2016; Valencia-Arias et al., 2024). However, the existing literature reviews on this topic have primarily focused on the systematic review of the relevant publications (Alrasheedi et al., 2015; Gupta et al., 2021; Kumar & Chand, 2018; Naveed et al., 2023; Pimmer et al., 2016; Valencia-Arias et al., 2024). Furthermore, some reviews have not primarily focused on using mobile learning in higher education. Thus, there remains a large gap in the literature on the situation of mobile learning in higher education. For example, Baran (2014) reviewed research on mobile learning in teacher education to identify trends and gaps. The findings showed an increasing trend in integrating mobile learning in teacher education, a lack of theoretical and conceptual perspectives in the published studies, the benefits of mobile learning in teacher education, and some challenges. Kumar and Chand (2018) reviewed systematic publications on the adoption of mobile learning. They found 27 publications, and their findings show that the adoption of mobile learning is one of the most understudied areas in the field. The investigation of factors influencing the adoption of mobile learning constitutes the majority of these studies. They concluded that attitudes, intention, ease of use, enjoyment, experience, usefulness, learning ability, and personal and social factors greatly influenced

mobile learning acceptance. However, they also found that other factors, such as interest, anxiety, technological, financial, and pedagogical factors, had little influence on mobile learning acceptance.

Naveed et al. (2023) presented a systematic literature review on mobile learning in higher education. They analyzed articles161 articles published between 2016 and 2022 and indexed in the Scopus and Web of Science databases. Their results showed that 70.8% of the studies were from developing countries, while 29.1% were from developed countries. In addition, they found that researchers with a percent 90% used a quantitative research design, a mixed methods research design was used in 7% percent of the studies, and a qualitative research design in only 3% of the studies. Alrasheedi et al. (2015) systematically reviewed studies to identify the success factors for effective mobile learning. They analyzed 30 studies and determined 13 critical success factors. Their analysis showed that users were quite satisfied with mobile learning in their courses and were interested in using the system more in the future. Furthermore, the findings showed that more than 61% and 77% of their participants had access to these services. Interestingly, about 66% of their participants had already used mobile learning platforms, and an overwhelming 88% were interested in using mobile phones for mobile learning purposes. Calderón-Garrido et al. (2022) systematically analyzed mobile phone use in the classroom. They analyzed 60 articles indexed in the Web of Science database between 2011 and 2020. They determined six specific areas regarding the usage of mobile phones in the classroom. They concluded that the use of mobile phones in classrooms is beneficial for educational purposes and presented a certain development for digital and media literacy to students and teachers.

The study of Tong et al. (2023) systematically reviewed mobile learning in teacher education for pre-service teachers from 2018 to 2023. They analyzed 27 publications. Their results showed that mobile learning is attracting interest in numerous nations worldwide. Their findings show that mobile learning positively impacts the development of knowledge, skills, and attitudes of pre-service teachers. They also found that mobile learning has advantages and challenges when implemented in the context of teacher education. Gupta et al. (2021) summarized the research on mobile learning technologies for students and teachers in higher education. They analyzed thirty-five studies. Their findings showed that research on pre-service teachers responded positively to mobile devices for learning regardless of age and gender. In addition, their analysis revealed that the mobile phone can be used as a communication tool to support teaching and learning.

Crompton and Burke (2018) summarized research on mobile learning in higher education from 2010 to 2016. Their findings showed that most research focused on examining the impacts of mobile learning on student achievement. Language learning was the most frequently studied subject area. The findings show that 74% of the studies involved students, and 54% took place in a formal education context. Pimmer et al. (2016) systematically analyzed 36 empirical studies on mobile learning in higher education. They found that as a particular advantage of mobile technology, “researchers in research on mobile learning in higher education used hybrid” designs. Also, they found little empirical evidence regarding the widespread use of mobile and ubiquitous learning in higher education. As a reason for this result, they indicated that mobile learning projects are primarily instructional but not transformative. Valencia-Arias et al. (2024) investigated mobile learning strategies in higher education and systematically analyzed publications in the Scopus and Web of Science databases. They used the PRISMA method to analyze the publications. Their results showed that the questionnaires were the main data collection tools and that Asian countries have published more publications on mobile learning in higher education.

Although certain scholars (Alrasheedi et al., 2015; Gupta et al., 2021; Kumar & Chand, 2018; Naveed et al., 2023; Pimmer et al., 2016; Valencia-Arias et al., 2024) have conducted systematic review studies on mobile learning in higher education, there has been a lack of bibliometric analysis on publications related to mobile learning in higher education. Bibliometric analysis encompasses examining literature and the interconnections among studies within a specific research topic or field. This analysis typically utilizes bibliographic data to evaluate, monitor, and comprehend scholarly output within a specific subject, field, or area of research. Additionally, it provides researchers with data regarding patterns in research and the diversity of the subjects examined. It has the function of collectively and consistently identifying the relevant information in a specific field to analyze research trends. Hence, it is essential to conduct a comprehensive investigation and analysis of research on the teaching and learning of mobile learning in higher education within the global university setting to determine prevailing research patterns in this domain. To address this gap in the existing body of knowledge, our objective is to conduct a thorough analysis of the research on

mobile learning in higher education institutions. The findings of this investigation will enable us to provide robust conclusions and evidence-based suggestions to shape and direct future educational research on the instruction and acquisition of mobile learning in higher education. We expect that the results of this investigation will enhance the progress of research on mobile learning. Specifically, this research aims to address the following research questions to examine the situation of mobile learning in higher education.

1. What is the number, change in publication years, and geographical distribution of publications on mobile learning in higher education in the twenty years from 2004 to 2023?
2. Which journals produced the most publications on mobile learning in higher education between 2004 and 2023?
3. Which countries produced the most publications on mobile learning in higher education between 2004 and 2023?
4. Which institutions produced the most publications on mobile learning in higher education between 2004 and 2023?
5. What are the research trends in publications on mobile learning in higher education from 2004 to 2023?

METHOD

Data Collection and Analysis

This study utilized the Scopus database as its primary source because the bibliometric database chosen for research should be compatible with the bibliometric software. In addition, the Scopus is one of the largest databases in the education field and is managed by Elsevier. To analyze the data, we used VOSviewer software 1.6.20. The software allows users to analyze the data and create visual bibliometric maps. For data collection, given that the definition of the screening term will impact the outcomes of the bibliometric analysis. Hence, this phase is paramount in the research process. We utilized the keyword “mobile learning” to search the Scopus database and retrieved the relevant data using the obtained phrases. The search query used in Scopus was, as follows: (KEY (m-learning) OR KEY (“m learning applications”) OR KEY (“mobile phone”) OR KEY (mobile) OR KEY (“m learning”) OR KEY (“m learning adoption”) OR KEY (mlearning) OR KEY (“m learning system”) AND KEY (“higher education”) OR KEY (“university students”) OR KEY (“undergraduate students”) OR KEY (graduate) OR KEY (graduates) OR KEY (“graduate education”) OR KEY (undergraduate).

In this study, the researcher established and utilized inclusion/exclusion criteria (filters) based on the research purposes. Accordingly, the inclusion criteria are, as follows:

(a) peer-reviewed articles,

(b) journals that are indexed in Scopus,

(c) articles on mobile learning as a research topic,

(d) articles with a focus on higher education in educational research,

(e) it must be written in English only, and

(f) it must have been published between 2004 and 2023.

The following are the exclusion criteria:

(a) conference papers, book chapters, editorials, etc.,

(b) articles that are not related to mobile learning,

(c) articles not related to higher education,

(d) written articles other than in English, and

(e) published before 2004 and in 2024.

For the data collection, we applied three fundamental filter criteria to the raw data collected using the search terms document type as journal articles, article language, and social science focus. The raw data from the search query were restricted to articles and early access documents to meet the initial inclusion criterion. The researcher excluded publications in foreign languages other than English and publications unrelated to

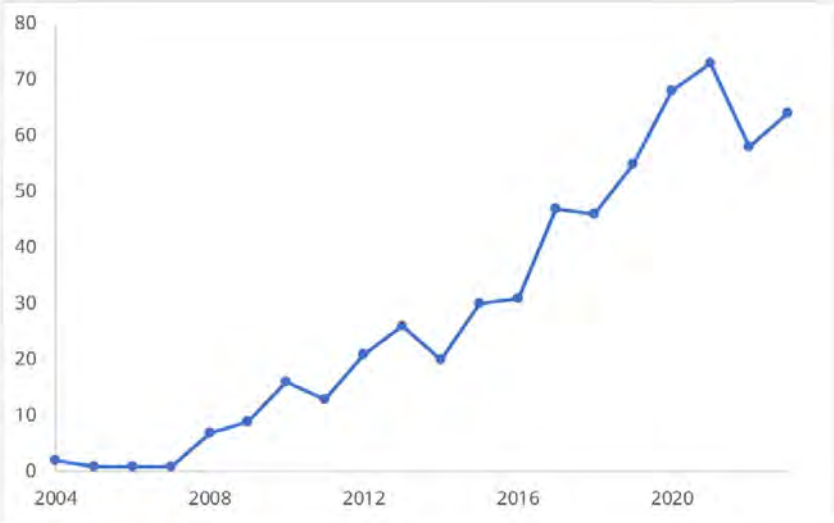

Figure 1. A comprehensive overview of research trends by year (Source: Authors)

mobile learning from the dataset based on inclusion-exclusion criteria. Included in the study were investigations on mobile learning and higher education, depending on the specific objectives of the research. The researcher initially sought to ascertain the relevance of the 621 publications to mobile learning by analyzing their abstracts and keywords. If the abstract and keywords did not include the study's keywords in the search query, the researcher reviewed the complete texts of the articles. Thus, two researchers completed collecting data for the included publications and were excluded from the data set. Consequently, 587 articles were identified, and the dataset was saved in May 2024, signifying the completion of the data collection process. After determining the studies involved in the analysis, the studies listed in Scopus were retrieved by selecting the "export" button. The data was downloaded into a single file and transformed into a "Tab-delimited file" format. This file was uploaded to the VOSviewer program for analysis.

We used the VOSviewer program to analyze the data. This program employs bibliographic matching analysis, keyword analysis, and bibliometric mapping to visualize the data. Using the VOSviewer program, we comprehensively analyzed the total number of publications and the bibliometric indicators. Specifically, VOSviewer allowed us to generate visual maps by analyzing citations, bibliographic matching, and co-occurrence of author keywords.

RESULTS

Figure 1 provides a comprehensive overview of research trends in mobile learning and higher education publications. **Figure 1** shows an increasing trend in articles on mobile learning in higher education. This result indicates that the number of publications regularly increases as the number of articles grows. Notably, although the number of articles decreased in 2011, 2014, and 2022, this decrease was smaller. Subsequently, the number of articles increased significantly after 2016. In 2017, 47 articles were published in the journal and indexed in the Scopus database. Accordingly, there was a peak in the number of studies in 2017. Although the number of publications stagnated in 2018, there was an upward trend after 2018. Although the number of published articles decreased slightly in 2022, the number of publications increased in 2023. Based on the results in **Figure 1**, it can be expected that the number of articles on mobile learning will continue to grow.

Productive Journals

Table 1 provides an overview of the top-ten productive journals in which the selected papers on mobile learning research in higher education were published and the corresponding number of papers published in each journal. This analysis shows that a significant proportion of the papers in this area were published in several prestigious journals. The leading journal for m-learning research proved to be Sustainability, in which numerous articles were published (n = 24). This number of articles on m-learning shows the growing interest and focus on the interface between mobile learning and higher education. After Sustainability, the second

Table 1. An overview of the top-ten productive journals

Journals	Number of articles	Citations	Total link strength
Sustainability	24	460	471
International Journal of Emerging Technologies in Learning	22	261	163
Education and Information Technologies	19	562	692
Journal of Surgical Education	18	376	22
Computers and Education,	17	2,274	491
International Journal of Mobile Learning and Organisation	13	149	205
Education Sciences	13	155	145
IEEE Transactions on Education	13	475	10
British Journal of Educational Technology	12	975	282
BMC Medical Education	12	369	72

journal is the International Journal of Emerging Technologies in Learning, in which 22 articles were published. After these two journals, the other journals, including Education and Information Technologies, Journal of Surgical Education, Computers and Education, Education Sciences, IEEE Transactions on Education, International Journal of Mobile Learning and Organisation, BMC Medical Education, and the British Journal of Educational Technology, also show notable contributions to the literature in this research area.

The results on the aim and scope of the most productive journals show that mobile learning is multidisciplinary. Furthermore, the same results show that mobile learning is used in educational sciences, technology, medical education, and learning technologies. Researchers favor these journals for publishing their findings and new developments in integrating mobile learning in higher education. As such, these journals allow researchers to access a wide range of mobile learning publications and follow research trends on the latest developments in the field. Overall, an analysis of the most prolific journals reveals the extent of research efforts by various disciplines, from education to medical education, to understand the application and use of mobile learning in higher education.

Regarding the number of citations of journals, the results show that The two journals with the highest citations are Computers and Education (2274) and the British Journal of Educational Technology (975). Although the Journal of Sustainability published more articles on the topic, it (460) does not have a high number of citations. Furthermore, the articles published in Education and Information Technologies have a high total link strength. This result means that the articles published in this journal have more relationships and interactions between articles examined within our dataset.

Prolific Countries

Table 2 shows the results regarding different countries' contributions to m-learning research in higher education from 2005 to 2023. The analysis showed that 91 countries/regions worldwide have actively participated in research on m-learning in higher education. The results in terms of geographical distribution of the articles we analyzed in **Table 2** show that the United States is the leader in m-learning research. The contribution of the United States amounts to almost 20% of the research on this topic. As the leading country, researchers from the United States have published 114 articles, a significant number. This number and ratio show the influential position of researchers from the United States. These results also mean that it is a country that has determined the direction and progress of m-learning research. This is followed by Spain and the United Kingdom, which significantly contribute to m-learning research with 52 and 49 publications, respectively. Australia, China, and Canada are also strongly represented, with over 30 published articles each. Malaysia, Saudi Arabia, Taiwan, and South Africa have contributed over 15 articles on this research topic. These countries are followed by India, Mexico, Thailand, Turkey, Hong Kong, Indonesia, the United Arab Emirates, and South Korea, with more than ten articles on the research topic.

According to the results on countries' citations in **Table 3**, the United States (4,887), Spain (1,180), and the United Kingdom (1,153) are the three countries with the most citations. In addition, researchers from Australia and China have more than 1,000 citations, although researchers from this country have published fewer articles than their colleagues from Spain and the United Kingdom. Australian authors have 1,305 citations, more than their Chinese colleagues (1,066). Regarding total link strength in **Table 3**, the United States (5,403), China (4,036), and the United Kingdom (2,601) are the three countries with the link strengths. In addition, Saudi Arabia (2,592) is a country that has a high link strength. This result shows that the Saudi Arabian

Table 2. An overview of prolific countries/regions (countries/territories and their number of articles [n])

Country	n	Country	n	Country	n	Country	n	Country	n
United States	115	Portugal	9	Cyprus	4	Ukraine	3	Haiti	1
Spain	52	Germany	8	Finland	4	Bahrain	2	Kyrgyzstan	1
United Kingdom	49	Greece	8	Italy	4	Bangladesh	2	Latvia	1
Australia	36	Japan	8	Romania	4	Fiji	2	Lebanon	1
China	36	Netherlands	8	Undefined	4	Jordan	2	Macao	1
Canada	34	Switzerland	8	Belgium	3	Kuwait	2	Malta	1
Malaysia	27	Ghana	7	Ecuador	3	Libya	2	Mongolia	1
Saudi Arabia	22	Nigeria	7	Guam	3	Lithuania	2	Montenegro	1
Taiwan	19	Pakistan	7	Iraq	3	Philippines	2	Morocco	1
South Africa	18	Viet Nam	7	Israel	3	Qatar	2	Namibia	1
India	17	Norway	6	Kazakhstan	3	Slovenia	2	Peru	1
Mexico	15	Czech Republic	5	Kenya	3	Argentina	1	Poland	1
Thailand	15	Egypt	5	New Zealand	3	Austria	1	Puerto Rico	1
Turkey	15	Iran	5	Palestine	3	Bosnia and Herzegovina	1	Rwanda	1
Hong Kong	14	Ireland	5	Russian Federation	3	Brunei Darussalam	1	Serbia	1
Indonesia	13	Oman	5	Singapore	3	Cambodia	1	Tanzania	1
United Arab Emirates	12	Brazil	4	Slovakia	3	Cameroon	1	Uganda	1
South Korea	11	Chile	4	Sweden	3	Denmark	1	Venezuela	1
Colombia	9								

Table 3. The top-ten prolific countries/regions

Countries	Number of articles	Citations	Total link strength
United States	115	4,887	5,403
Spain	52	1,180	2,193
United Kingdom	49	1,153	2,601
China	36	1,066	4,036
Australia	36	1,305	2,188
Canada	34	846	1,530
Malaysia	27	750	1,604
Saudi Arabia	22	567	2,592
Taiwan	19	378	1,385
South Africa	18	616	576

researchers' articles have more relationships and interactions between articles examined within our dataset, even though the citation numbers are low compared to the top-3 countries.

Figure 2 illustrates a mapping of the newly published countries to mobile learning. We selected countries that published more than 5 articles on mobile learning during this analysis. The results show that emerging countries are publishing on mobile learning. The lighter yellow links show the countries that have published more recently. According to this, India, Saudi Arabia, Thailand, Indonesia, and Germany are countries that have recently published on mobile learning. Before these countries, China, Taiwan, and Malaysia published articles. The average publication year of these countries is 2018. The United States, Spain, the United Kingdom, and Australia are countries with a long history of research, as shown in **Figure 2**.

Prolific Institutions

The most prolific institutions' analysis results show an analysis of international cooperation in m-learning research. The results show the global nature of this research topic and the joint efforts of researchers from different countries. The results of the institution's analysis revealed 160 countries. Accordingly, the results show researchers' widespread interest and joint initiatives to explore the potential of m-learning in higher education. Such international collaboration promotes knowledge exchange, cross-cultural perspectives, and enriching research findings in mobile learning. In terms of institutions, we found that between 2005 and 2023, 160 institutions from around the world contributed to research in the field of m-learning (see **Table 4**). The top-ten institutions include Universidad de Granada, The University of Hong Kong, Universiti Sains Malaysia, Tecnológico de Monterrey, University of Toronto, King Abdulaziz University, Old Dominion University, The University of British Columbia, Universidade de Aveiro and Queensland University of Technology. These institutions have a relatively high productivity of articles on mobile learning.

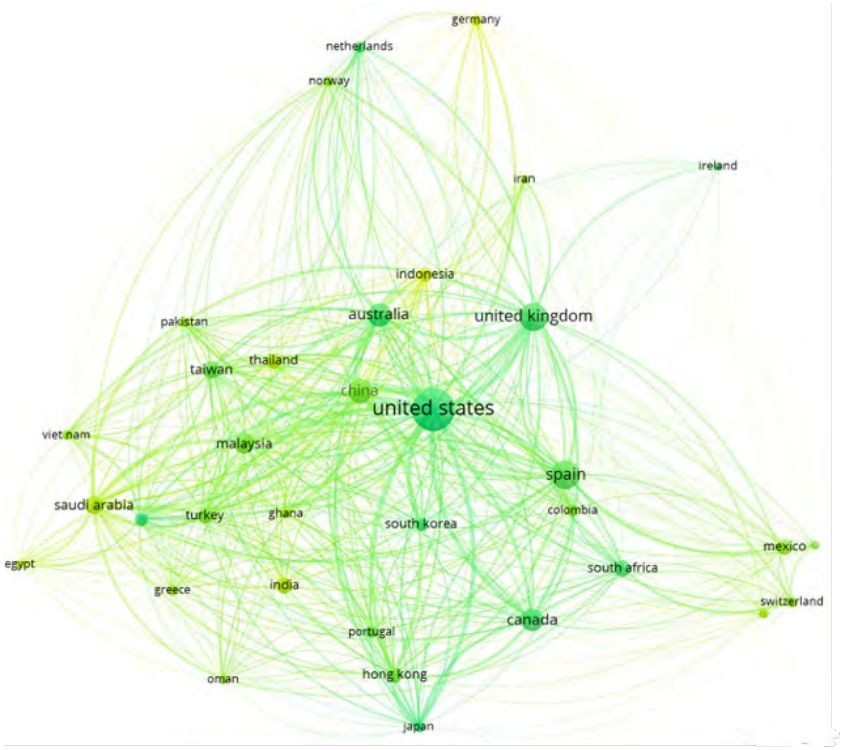

Figure 2. Mapping of newly published countries on mobile learning (Source: Authors' data)

Table 1. An overview of prolific institutions

Institutions	Countries	Number of articles
Universidad de Granada	Spain	11
The University of Hong Kong	Hong Kong	10
Universiti Sains Malaysia	Malaysia	9
Tecnológico de Monterrey	Mexico	8
University of Toronto	Canada	7
King Abdulaziz University	Saudi Arabia	6
Old Dominion University	United States	6
The University of British Columbia	Canada	6
Universidade de Aveiro	Portugal	6
Queensland University of Technology	Australia	5

The results show that the most prolific institutions are Canada, Spain, Hong Kong, Malaysia, Mexico, Canada, Saudi Arabia, the United States, Portugal, and Australia. Based on this result, it can be concluded that Canada has the most prolific institutions. Among institutions, two institutions, including Universidad de Granada and Universidade de Aveiro, are from Europe, three institutions the University of Toronto, The University of British Columbia, Tecnológico de Monterrey and Old Dominion University, are from North America, and the other four institutions, including The University of Hong Kong, Universiti Sains Malaysia, and King Abdulaziz University, are from Asia; the remaining institution, Queensland University of Technology, is from Australia.

Research Trends

We conducted a keyword co-occurrence analysis in the VOSviewer program to identify research clusters and trends. We found 3,381 keywords in 587 articles. Using this analysis, we selected the keywords that appeared more than ten times in the keyword co-occurrence analysis. Thus, the analysis results yielded 92 keywords in 587 articles. The map in **Figure 3** displays the connections between two nodes and represents the relationships among the nodes. The size of each node corresponds to the frequency of the respective keywords in the keyword co-occurrence analysis. The most popular keywords are higher education, students, mobile learning, e-learning, mobile devices, m-learning, human/humans, female, male, and adult. VOSviewer allows researchers to have research clusters among the studies we reviewed. Thus, we obtained the research

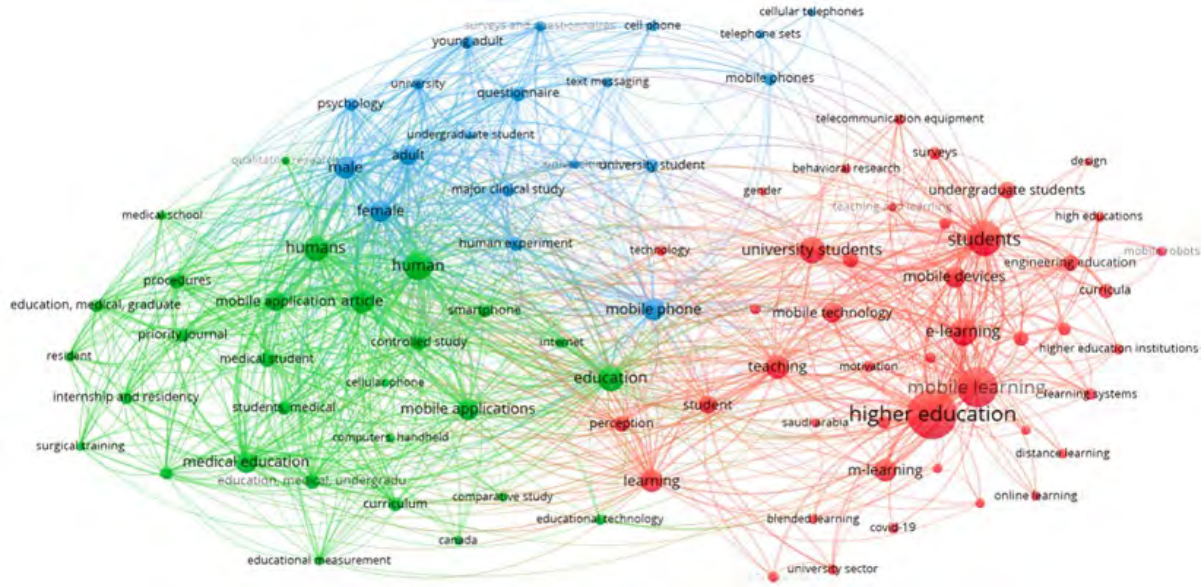

Figure 3. Map from keyword co-occurrence analysis (Source: Authors' data)

clusters representing the most relevant and popular keywords on mobile learning in higher education. Our results yielded 3 research clusters.

1. The red cluster includes 44 keywords. These are academic performance, augmented reality, behavioral research, blended learning, computer-aided instruction, COVID-19, curricula, design, distance education, distance learning, e-learning, education computing, engineering education, gender, high educations, higher education, higher education institutions, learning, learning systems, m-learning, mobile computing, mobile devices, mobile learning, mobile robots, mobile technology, motivation, online learning, perception, Saudi Arabia, smartphone, students, surveys, sustainability, teaching, teaching and learning, technology, technology acceptance model, technology adoption, telecommunication equipment, undergraduate students, university sector, university student. Among these keywords, the most used are higher education, mobile learning, e-learning, m-learning, mobile devices, learning, education computing, engineering education, perception, student, teaching, and university students. These keywords mean that research in this cluster focused on building a learning environment for students to engage them in learning using mobile devices. In particular, a part of the research in this cluster was conducted with engineering students. These findings show that the mobile learning environment has facilitated and engaged students learning in higher education settings.
2. The green cluster includes 29 keywords. These are article, Canada, cellular phone, clinical competence, comparative study, computers, handheld, controlled study, curriculum, education, education, medical, graduate, education, medical, undergraduate, educational measurement, educational technology, human/humans, internet, internship and residency, medical education, medical school, medical student, mobile application/applications, priority journal, procedures, qualitative research, resident, smartphone, students, medical, surgical training. Among these keywords, the most used are human/humans, internship and residency, medical education, procedures, mobile application/applications, clinical competence, controlled study, and graduate and undergraduate medical. These keywords mean that research in the green cluster focused on mobile learning in medical education. These findings show that the mobile learning environment has been used to facilitate and support medical graduate and undergraduate students learning.
3. The blue cluster includes 19 keywords. These are adult, cell phone, cellular telephones, female, human experiment, major clinical study, male, mobile phone/phones, psychology, questionnaire, surveys/questionnaires, telephone sets, text messaging, undergraduate student, universities/university, university student, and young adult. Among these keywords, the most used are female, adult, male, mobile phones, questionnaire, and young adult. These keywords show that research in the blue cluster focused on examining young adult people's use of mobile phones in

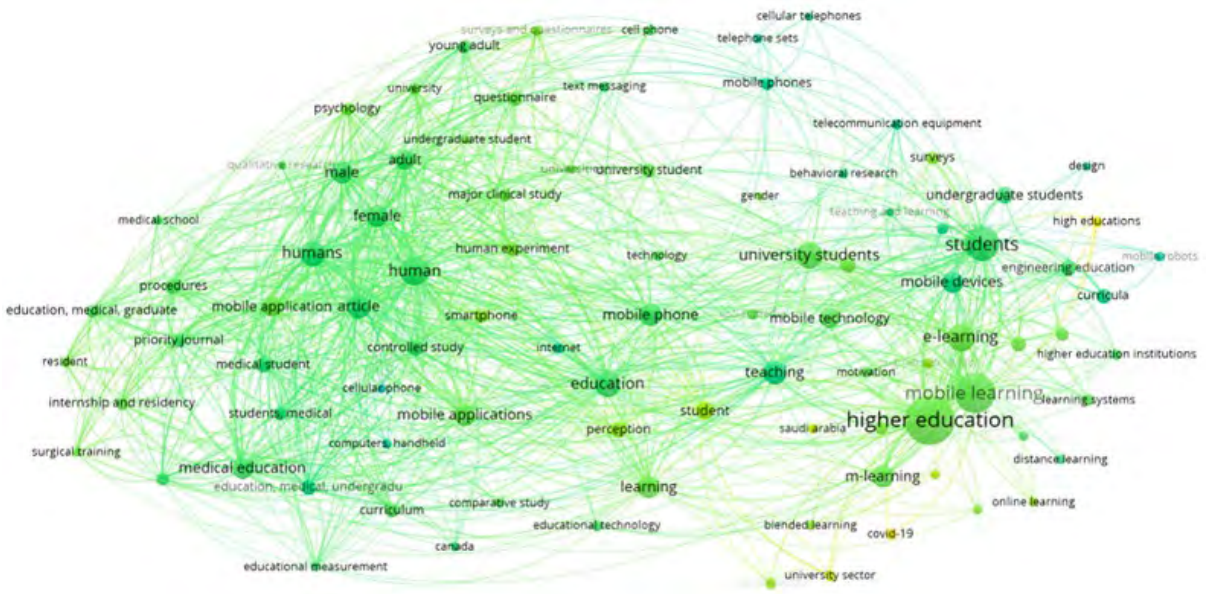

Figure 4. The use of keywords in research on mobile learning in higher education by year (Source: Authors' data)

learning using surveys and questionnaires. These findings show that researchers in this cluster examined the perceptions of university students who enrolled as young adult people at the universities toward mobile learning adoption. Based on the keywords, we understand that researchers used surveys and questionnaires in this cluster.

Figure 4 shows the use of keywords in research on mobile learning in higher education by year. Accordingly, **Figure 4** shows the recent emergence of keywords and new trends in research on mobile learning in higher education over the twenty years. The keywords colored in yellow indicate the time when the most recent keywords used in research appeared more recently. The map in **Figure 4** shows that the most recent studies in mobile learning research focus on the COVID-19 pandemic (occurrences: 14; average publication year: 2022.07). In addition, the map results in **Figure 4** show that recent studies also focused on academic performance (occurrence: 12; average publication year: 2020). Before academic performance was a trending topic, the results in **Figure 4** show that augmented reality was a research trend (occurrence: 13; average publication year: 2019.69). Furthermore, the results showed that most research was conducted in Saudia Arabia as it was one of the keywords that appeared recently (occurrence: 13; average publication year: 2021). This finding shows that researchers in Saudi Arabia are interested in mobile learning in higher education and are publishing more papers about it. Another finding is that research with adults (occurrence: 48; average year of publication: 2017.29) and young people (occurrence: 20; average year of publication: 2017.15). Finally, the results also show that research with engineering education (occurrence: 33; average publication year: 2016.91) and students were conducted before 2020, as shown in **Figure 4**. This finding means that studies with mobile learning and engineering education were a trending topic before 2020 because the average publication year was 2016.91.

DISCUSSION

This study aimed to thoroughly investigate and analyze the progress and implementation of mobile learning in higher education to determine research trends. The results show that the number of publications regularly increased after 2016. Accordingly, the number of studies peaked in 2017, with an upward trend after 2018. This finding aligns with the findings of Crompton and Burke (2018), Kumar and Chand (2018), Tong et al. (2023), and Valencia-Arias et al. (2024). This research shows that the number of publications on mobile learning will continue to increase. The results regarding prolific journals show that many articles in this field were published in several prominent journals. The leading journal for mobile learning research proved to be Sustainability, in which numerous articles were published. This number of articles on mobile learning shows

the growing interest and focus on the interface between mobile learning and higher education. After Sustainability, the second journal is the International Journal of Emerging Technologies in Learning. The following other journals, including Education and Information Technologies, Journal of Surgical Education, Computers and Education, Education Sciences, IEEE Transactions on Education, International Journal of Mobile Learning and Organisation, BMC Medical Education, and the British Journal of Educational Technology, also have notable contributions to the literature in this research area.

Our results in terms of prolific countries revealed that 91 countries/regions worldwide have actively participated in research on mobile learning in higher education. The results in terms of geographical distribution revealed that the United States has the most publications and produced amounts to almost 20% of the research. This number and ratio show the influential position of researchers from the United States. These results also mean that the country has determined the direction and progress of mobile learning research. The United States is followed by Spain and the United Kingdom, which significantly contribute to m-learning research with 52 and 49 publications, respectively. Australia, China, and Canada are also strongly represented, with over 30 published articles each. Malaysia, Saudi Arabia, Taiwan, and South Africa have contributed over 15 articles on this research topic. This result is similar to Naveed et al. (2023). These findings indicate that the United States' prominence in research can be attributed mainly to its greater frequency of publications and substantial research partnerships for research in the topic. It is well known that this nation has emerged as a significant advocate for advancing innovation in mobile learning environments. The allocation of resources towards innovation and research may have fostered the growth and advancement of research in this field.

Our examination of recently published countries in mobile learning has shown that India, Saudi Arabia, Thailand, Indonesia, and Germany recently released mobile learning publications. In addition, our results showed that the United States, Spain, the United Kingdom, and Australia have a long history of research. The results for the number of country citations show that the United States, Spain, and the United Kingdom have the most citations. In addition, Australia and China have more than 1,000 citations, according to these three countries. The results in terms of total link strength show that the United States, China, and the United Kingdom are the three countries with the highest link strength. We also found that Saudi Arabia has a high link strength. This result means that Saudi Arabian researchers' articles have more relationships and interactions among the articles examined in our data. In terms of the most productive institutions, the results showed that Canada has the two most productive institutions. Two institutions, including Universidad de Granada and Universidade de Aveiro, are from Europe, three institutions, the University of Toronto, The University of British Columbia, Tecnológico de Monterrey and Old Dominion University, are from North America and the other four institutions, including The University of Hong Kong, Universiti Sains Malaysia and King Abdulaziz University, are from Asia; the remaining institution, Queensland University of Technology, is from Australia. This result shows that the institutions that have contributed to the research are from different continents, and the most productive institutes and countries/regions are mostly located in the United States and Europe.

In addition, the results of the keyword co-occurrence analysis in the VOSviewer program to identify research clusters and trends revealed 3 research clusters. Based on the results, the first cluster focused on building a learning environment for students to motivate them to learn with mobile devices. Part of the research in this cluster was conducted with engineering students in particular. The results show that the mobile learning environment facilitated students' learning in higher education and engaged them in teaching. The second cluster focused on mobile learning in medical education. The results show that the mobile learning environment facilitated and supported medical students' learning. In addition, the third cluster focused on investigating young adults' use of mobile phones in learning through surveys and questionnaires. This is similar to those of Naveed et al. (2023). The results show that the researchers in this cluster investigated the perceptions of university students enrolled as young adults in universities regarding the adoption of mobile learning. Research findings on using keywords in mobile learning studies in higher education, organized by year, indicate that more recent investigations also prioritize academic performance. Specifically, investigating the integration of mobile learning during the COVID-19 pandemic presents a chance for higher education institutions to transform and digitally guarantee the uninterrupted delivery of education.

Before the rise in interest in academic performance, the findings indicated that augmented reality was a prominent area of research. Our findings about academic performance confirm the results of Crompton and Burke (2018). Moreover, the findings indicated that most studies were conducted in Saudi Arabia, as it emerged as a prominent keyword recently. This finding indicates that researchers in Saudi Arabia have a keen interest in implementing mobile learning in higher education and are producing more academic papers on the subject. Additionally, research is being conducted with both adults and young individuals. Furthermore, the findings indicate that research on engineering education and students was carried out before 2020. The findings indicate that research on mobile learning and engineering education gained significant popularity in the period leading up to 2020, particularly around 2016.

CONCLUSION

Although mobile learning has attracted considerable attention in educational research and practice, to our knowledge, we could not find any study that uses bibliometric analysis on mobile learning to identify research trends in the higher education context. To gain a comprehensive understanding of the use of mobile learning in higher education, this study examined peer-reviewed articles from higher education between 2004 and 2023. We aimed to present an analysis of publications on the development of mobile learning research worldwide to provide conclusions and recommendations for future research studies. The results show that research has gradually increased over the last twenty years. Furthermore, the results showed an evolving trend in mobile learning research over time. This finding shows a significant change in mobile learning research. We found that recent studies show a trend toward building a learning environment for students to motivate them to learn with mobile devices. Recent research has shown a particular interest in academic performance and augmented reality. Furthermore, our findings have shown that research in mobile learning spans a long time, and a paradigm shift has occurred over the last twenty years. In terms of research trends, our findings showed that there are three clusters of research. The first cluster focused on building a learning environment for students, while the second cluster included research on mobile learning in medical education. In addition to these findings, the third cluster investigated young adults' use of mobile phones in learning through surveys and questionnaires.

The most productive journals included Sustainability, the International Journal of Emerging Technologies in Learning and Education, and Information Technologies. Furthermore, the results showed that the most productive institutes and countries/regions were mostly located in the United States and Europe. In this review, we have also highlighted the research trends on the use of mobile learning in higher education. However, it is important to note that the integration of mobile learning in higher education is still very superficial. For this reason, further studies are needed that focus on integrating mobile learning and present a comprehensive curriculum system for integrating m-learning in higher education. Researchers have studied the various aspects of mobile learning regarding educational outcomes. However, there is still much to be done to explore the benefits of mobile learning. This may be because there is no consensus on integrating mobile learning into the curriculum and because of some barriers and challenges to using mobile learning.

Limitations

The study is limited to articles in the Scopus databases based on the keywords the researcher uses for search according to inclusion and exclusion criteria. Important citation indexes in the Scopus database, representing a significant data source with its content, were selected to examine the studies conducted worldwide. Articles published in 2024 were not included in the analysis. Another limitation of this study is that the articles analyzed in the Scopus database were published between 2004 and 2023 were published in English. In addition, only articles published in English were included in the study.

Recommendations

This study conducted a bibliometric analysis of articles on mobile learning published in peer-reviewed journals indexed in the Scopus database. From this perspective, the results of this research examined the current state of educational research on mobile learning in higher education. They identified the authors, institutions, and countries contributing to the literature. In addition, using keyword analysis in VOSviewer, the

study presented data on the most frequently used keywords in the literature to identify research trends. For future research, it is possible to conduct further bibliometric analyses of published studies investigating the application of mobile learning in different fields. It is also possible to use VOSviewer to conduct a bibliometric analysis of studies in the other databases, including Web of Science, ERIC, and the Elsevier databases. In future research, researchers can use the content analysis method to demonstrate the advantages and benefits of mobile learning studies for higher education students and lecturers. From this point of view, our findings serve as a basis for future research.

Furthermore, we suggest that future research should conduct a systematic review to identify the multidisciplinary use of mobile learning in different domains. Such a review will allow researchers to consider various perspectives and methodologies to identify the benefits and advantages of mobile learning in higher education. In addition, researchers need to examine the reciprocal contributions of mobile learning to teaching and assessment methods and techniques. Understanding these contributions could show how mobile learning with mobile tools such as cell phones and tablets can be used and adapted in higher education. Future studies should focus on integrating mobile learning into the classroom by identifying the barriers and challenges to deeper integration and proposing implementable solutions. In addition, researchers should also consider the ethical and practical implications of mobile learning for higher education. Researchers can contribute to advancing mobile technologies in higher education by addressing these issues in further research. These contributions will promote more effective teaching and learning methods and better prepare students for the challenges and opportunities of the 21st century.

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