International Journal of Learning, Teaching and Educational Research
Vol. 20, No. 10, pp. 291-312, October 2021
https://doi.org/10.26803/ijlter.20.10.16
Received Aug 06, 2021; Revised Oct 22, 2021; Accepted Oct 28, 2021

A Visual Pattern of Two Decades of Literature on Mobile Learning: A Bibliometric Analysis

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Abstract. Mobile learning, or m-Learning, has grown in popularity significantly over the last few decades, as evidence of educators and students worldwide using the device as a teaching and learning tool continues to accumulate. The pattern of mobile-learning research from 2001 to 2020 is determined by bibliometric analysis. The study retrieved 3,874 documents for further analysis, based on the keywords associated with mobile learning in the article's title. The maps depicted the connections between the researchers, countries, all keywords, titles, and abstracts. The title and abstract of this study are used to visualise the co-occurring terms of various phases or concepts associated with mobile learning that were extracted from the Scopus database. The findings indicate strong and direct connections between the concepts in e-learning, implying a significant and direct research connection. China was the leading country in mobile-learning research, and the leading journal was *Computers and Education*. The top author's keywords in terms of co-occurrence were "mobile learning", "e-learning", "students", "learning systems", and "m-learning". To conduct a two-decade analysis, this study excludes any publications from the years 1984 and 2021. These critical analyses of prior work are valuable and indispensable resources for mobile-learning scholars and practitioners. It is believed that online-learning applications have increased students' engagement; and it has eliminated the accessibility gap. Consequently, mobile learning is expected to maintain its popularity over the next few decades.

Keywords: mobile learning; m-learning; Scopus; bibliometric analysis; VOS-viewer

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1. Introduction

Mobile learning, also known as m-learning, is growing in popularity, as technology and multimedia advance. Prillya et al. (2021) define mobile learning as a technology that can be used to acquire knowledge from anywhere; and it can give complete support in attaining effective learning and early appearance, as well as an assessment-based initial appearance. Mobile learning has increased in popularity recently, due to the ease with which the internet can now be accessed (Díaz-Sainz et al., 2021; Goksu, 2021). It connects the data (Sungur-gul, 2021); and it facilitates learning in various fields (Barrett et al., 2021; Díaz-Sainz et al., 2021). According to Huang et al. (2021), mobile learning is defined as learning that occurs on mobile devices that can be accessed at any time, and from any location (Akour et al., 2021; Mutiaraningrum & Nugroho, 2021).

Simultaneously, mobile applications serve as mobile-learning devices (Goksu, 2021). Today, a variety of mobile devices are available, including smartphones, laptops and tablets. As a result of contemporary technological advances, learners now have access to affordable, more convenient, new, accessible, portable, and digital technology (Criollo-C, Guerrero-Arias et al., 2021). Students can create, own, transform, discuss, discard, share, store and disseminate ideas, opinions, images and information through mobile learning, thereby transforming their identities and communities. Due to their portability and ubiquity, mobile devices have become indispensable in our daily lives, and particularly in the educational sector (Akour et al., 2021; Díaz-Sainz et al., 2021; Sungur-gul, 2021).

Mobile technology has the potential to shift the educational paradigm away from imposed instruction and towards cooperative learning (Criollo-C, Moscoso-Zea et al., 2021). As a result, mobile devices and their capabilities revolutionise and enhance current educational practices (Criollo-C, Guerrero-Arias et al., 2021; Har et al., 2019).

The usage and effects of mobile learning have been extensively addressed, by researchers in the educational theoretical aspect, such as in a technology-acceptance model and in a mobile-technology acceptance model (Moya & Camacho, 2021; Yuan, et al., 2021). The question arises about pedagogy that has stood out in digital literacy, while the technological resources category has had the least-relevant assessment by researchers (Moya & Camacho, 2021). Indeed, interactions seem to be a major challenge experienced by students ; since they hinder the effectiveness of mobile learning (Yuan et al., 2021).

Consequently, practitioners and researchers need to have a clearer definition and a better description of the idea, allowing them to design a learning experience that is supported by more effective and flexible mobile technology (Viberg et al., 2021). Thus, these issues require looking at the pattern of co-occurrence analysis over these two decades, which has addressed the most frequently discussed mobile-learning topics among academics and the areas of mobile learning that require additional research.

Therefore, this study was conducted by using Microsoft Excel, Harzing's Publish or Perish, and VOS-viewer software, in order to analyse the data and the visualisation of the research-publication pattern on mobile learning. The evolutionary analysis and the co-occurrence analysis through VOS-Viewer, a software tool for creating and visualising bibliometric networks, was used to explore the evolutionary process of mobile-learning research, and to predict the future developmental trends.

2. The Literature Review

Nowadays, mobile-device learning is integrated into almost all knowledge-related activities in the classroom (Díaz-Sainz et al., 2021; Nurul & Nailul, 2018). As today's young learners, dubbed digital natives, have developed technical skills that enable them to succeed through mobile-device learning, they are constantly drawn to cutting-edge technologies, having grown up with internet access, social media, and mobile devices. As a result, mobile learning has emerged, as being the primary strategy for educational innovation, rapidly growing in popularity and resulting in widespread educational innovation (Criollo-C, Guerrero-Arias et al., 2021; Díaz-Sainz et al., 2021).

With mobile learning's continued growth, there have been attempts to compile data on the global scientific output of mobile-learning studies (Elaish et al., 2019). According to Shi et al. (2020), bibliometric analysis is a valid and potentially equitable method for quantifying a paper's contribution, in order to assist academics when studying this subject by narrowing their future research directions among the numerous current methods for analysing the literature. As a result, bibliometric analysis is frequently used to determine the patterns and impacts, including publishing countries, subject fields, journals and authors' keywords (Donthu et al., 2021).

Due to the increase in the number of studies on mobile learning, the strength of the relationship between new mobile applications and mobile-learning activities is getting stronger; it has been recognised that mobile learning is a critical and growing field for improving learning performance. Although there are many studies on mobile learning, research by using bibliometric visualisation-mapping methods in a broad context and presenting network maps in diverse variables is still ongoing, which includes the keywords of mobile learning. As such, it is critical to provide an up-to-date map, visualisation and clustering of a mobile learning publication timeline for the Scopus datasets between 2001 and 2020. The current study identifies the visualisation of mobile-learning patterns; and it makes some recommendations for the direction of future research.

As such, this study will analyse and visualise the two-decade body of literature on mobile learning from 2001 to 2020. The study's research question is, first and foremost, what is the recent publication pattern in mobile learning? Secondly, what is the current citation pattern for mobile-learning publications? Thirdly, what are the most frequently discussed mobile-learning topics among academics? Finally, what areas of mobile learning still require additional research?

3. The Method

The method used in this study is based on the data gathered and filtered through to a definitive collection of reliable and suitable data for analysis. The topic and scope of the study must be determined first in the context of the purpose of the study; in this case, we want to focus on all the studies related to mobile learning and published in the Scopus database. Scopus was chosen; because it is the world's largest abstracting and indexing database, as well as one of the largest searchable databases of citations and abstracts (Ahmi & Mohamad, 2019; Ahmi & Mohd Nasir, 2019; Burnham, 2006). The database includes 67 million records from more than 22,500 serial titles, 96,000 conferences, and 136,000 books published by more than 7,500 different publishers worldwide (Cantu-Ortiz, 2017).

As illustrated in Figure 1, PRISMA was adopted from Moher et al. (2009), to select the documents for this study, based on the research process. The data were extracted on 4th May 2021; and the following keyword combination was used to identify all the target publications on "m-learning" or "mobile learning".

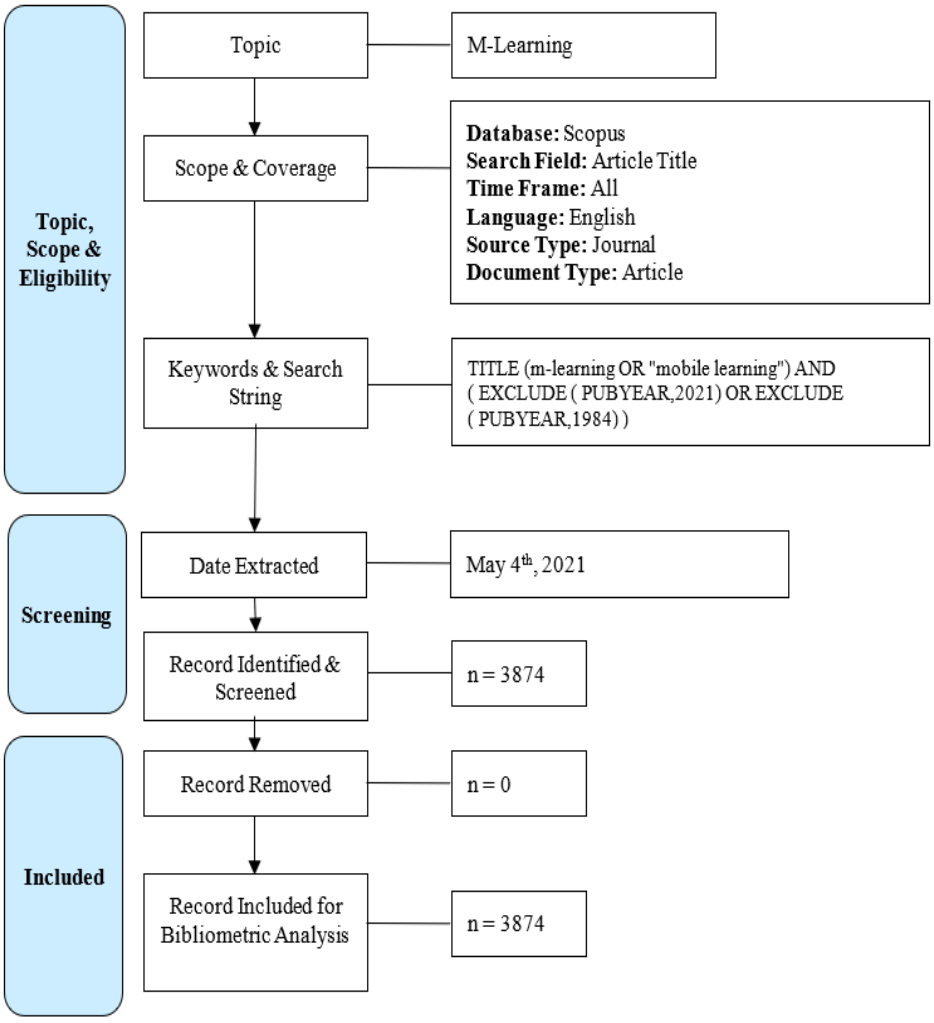

Figure 1: The research protocol

Due to the scarcity of bibliometric studies on mobile learning, we limited our search to those documents relating to mobile learning or m-learning works. As Donthu, et al. (2021) state that the scope of bibliometric analysis is broad; and the dataset is large. TITLE (m-learning OR "mobile learning") AND (EXCLUDE (PUBYEAR, 2021) OR EXCLUDE (PUBYEAR, 1984)). This query returned 3,874 documents. A series of data-cleansing operations revealed that there were no duplicate documents. As a result, the same number of documents was retained following the process. The data were then exported as research information systems (RIS) and comma-separated values (CSV) files. The primary search-query TITLES ("m-learning" and "mobile learning" and "bibliometric analysis") were used in this study to determine how much of this field had been studied previously by using bibliometric analysis; and the query returned only one result.

The dataset contains information about publications, including their type, year, the language of publication, subject area, source title, keywords, abstract, country of origin, affiliation, citations, and authorship. We performed most of the mapping analysis in this study by using the VOS-viewer software (Ding & Yang, 2020; Van Eck & Waltman, 2020). Hence, the importance and power of the linkages reflected by the network's size and interconnecting interlinking lines from the co-occurrent maps.

4. The Results

The following aspects of scholarly works were analysed to address the research questions: document types, source types, document languages, subject area, publication by year, publication by country, publication by source title, publication by institutions, citation patterns in mobile learning, based on the keywords and titles, as well as by the citation patterns. Most of the data were in the form of frequencies and percentages. In addition, the publisher's name, the current Cite Score, the SCImago Journal Rank (SJR) 2020, and the Source Normalized Impact per Paper (SNIP) 2020 for the most active source title, as reported by Scopus, were included.

SJR quantifies the weighted citations received by the source title; whereas SNIP quantifies the number of actual citations compared to the expected number of citations for the source title's topical field (Hitchcock, 2004). The citation analysis was in the form of citation metrics, and the twenty most-cited publications.

4.1 Recent Trends in Mobile Learning Publication

What has been the recent pattern of mobile learning publication? We analysed the publication pattern in mobile learning by using bibliographic data to address this question. This study used the total number of publications by year, document type, publication by source title, publication by country, and the publication by subject area.

4.1.1 Year of Publication

Table 1 shows the yearly publications on m-learning/mobile learning in detail, such as the total number of publications (TP); the total number of cited publications (NCP); the total number of citations (TC); the average number of

citations per publication (C/P); the average number of citations per cited publication (C/CP); the h-index (h); and the g-index (g). According to the Scopus database, there is one article from 2001 that serves as the foundation for the research on the use of mobile learning in educational settings. Abernathy (2001) wrote the first paper. Further examination of this document has revealed that it is composed of brief writings in the form of magazine articles.

Interestingly, these papers have received only one citation, indicating the establishment of a new research environment by *Talent Development* magazine, the pioneers of mobile-learning publications. Additionally, this article was from the training and development cluster, specifically e-learning. This cluster implies that authors/researchers/practitioners pioneered the mobile-learning movement in the e-learning genre. The term "wireless" used in this study discusses the impact of mobile learning on training and the development that utilises face-to-face and remote methods, with instructors facilitating learning via laptops.

Table 1: Year of publication

Year	TP	NCP	TC	C/P	C/CP	*h*	*g*
2001	1	1	40	40	40	1	1
2002	10	10	455	45.5	45.5	8	10
2003	9	9	610	67.78	67.78	6	9
2004	16	12	390	24.38	32.5	7	16
2005	55	51	1360	24.73	26.67	15	36
2006	64	51	655	10.23	12.84	17	23
2007	121	87	2537	20.97	29.16	19	49
2008	126	100	1936	15.37	19.36	21	42
2009	166	118	3486	21	29.54	21	58
2010	253	181	3822	15.11	21.12	29	57
2011	220	159	3030	13.77	19.06	24	52
2012	291	206	4627	15.9	22.46	33	64
2013	249	188	2899	11.64	15.42	23	48
2014	337	228	2796	8.3	12.26	27	46
2015	335	241	2699	8.06	11.2	28	41
2016	322	235	2784	8.65	11.85	28	43

2017	314	235	1819	5.79	7.74	21	31
2018	317	213	1833	5.78	8.61	18	33
2019	343	121	1356	3.95	11.21	19	24
2020	325	124	428	1.32	3.45	9	14
Total	3874						

In 2002, nine proceedings and one journal article on educational research contexts were published. Sharples et al. (2002) published an article on designing and implementing a mobile-learning resource for their children aged 9-11 by using a Fujitsu Stylistic LT Pen Tablet computer, or a HandLeR prototype. The prototype produced is based on a Conversational Framework that divides the system into two modules, which encourage a deliberate cycle of action and reflection to support a variety of activities and learning abilities, rather than adapting to specific learners. The action operations allow students to share their experiences through pictures, voices and written notes, to perform experiments, and to communicate with teachers and other students. However, the description provided can enable students to manage, connect and combine the online-learning activities by applying current and previous knowledge.

Attewell and Gustafsson (2002), Mifsud (2002), Nyiri (2002), Seppälä and Alamäki (2002), Seppälä et al. (2002) and Uther (2002), presented their research papers at the IEEE International Workshop on Wireless and Mobile Technologies in Education, WMTE 2002. These researchers were interested in the philosophy, the fundamental principles, the perceptions, and the challenges associated with transforming formal learning into mobile learning, conducting pilot tests on the use of mobile technology in teacher-training, developing prototypes by using mobile technology, and identifying pedagogical applications that are beneficial to higher education.

The findings indicate that flexible teaching solutions that enable students to access information via a variety of devices, and which support learning in various settings are necessary to engage young adults in learning, and to assist them in developing and achieving their lifelong learning objectives. However, this depends on the extent to which current knowledge regarding usability is best applied. Thus, this indicates improvement in the research foundations on the development and use of mobile-learning tools and environments by educators in an educational system that is increasingly moving towards student-centred learning by learners at any time and from any location.

Ichinohe and Suzuki (2002) and Houser et al. (2002) have used mobile devices in language learning, such as mobile-phone websites, cell phones, and Personal Digital Assistants (PDAs), among adult learners. These studies have contributed to revolutionising and quantifying the effects of mobile learning on learning activities; and they are then incorporated into a language-learning curriculum.

Although researchers were concerned about the future of mobile learning, the study of Lo et al. (2002) developed techniques for using multi-agent systems in mobile learning platforms, in order to enhance interaction and communication between teachers and their students. This technique allows the actual needs of each student to be determined by the instructor. In addition, the use of user-client agents can monitor students' progress in multi-agent platforms, while assisting developers in delivering international mobile-production applications. This leads to developing a mobile-learning environment into a truly dynamic and global environment. These articles frequently emphasise the flexible lesson needed, in order to accomplish the learning objectives via a wireless feature in mobile learning.

Thus, these two years of pioneering articles have established a precedent for mobile learning; and they have been cited 495 times. According to records, between 2002 and 2003, the publication grew at a relatively slow pace, reaching less than 3% in 2013; however, in early 2004, a growth of 4.34% in the number of articles published was observed. This trend fluctuated, but there was still an average of 100, 200, and 300 publications per year. The highest number of publications occurred in 2019, with 343 documents, which comprises 93%. This observation denotes the irregular and peak period of the trending practice, as exemplified by educators worldwide, who employ a mobile-learning approach, as shown in Figure 2.

This scenario was understandable when the following study was conducted, particularly in the light of those countries that were participating in this study.

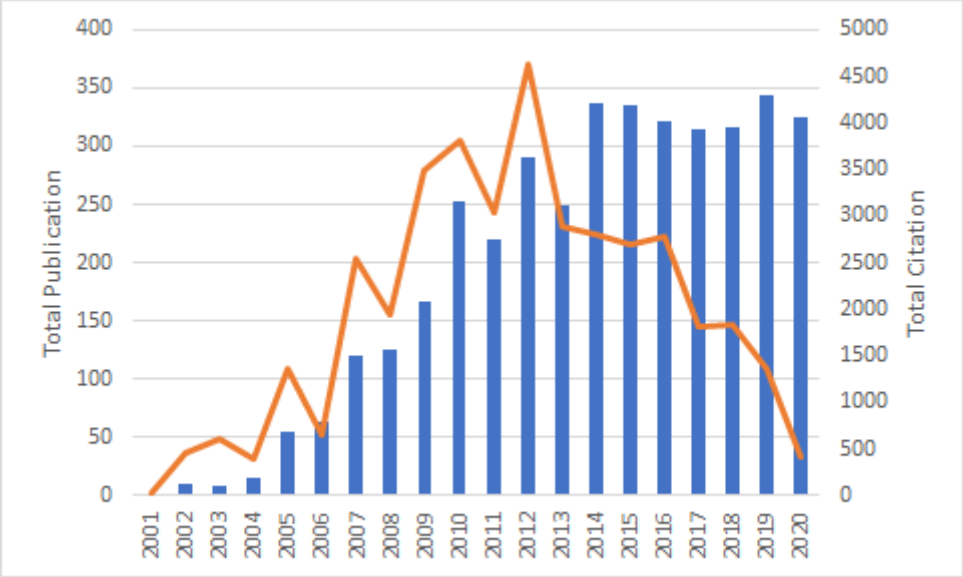

Figure 2: Total publications and citations by annal trends in mobile-learning studies

4.1.2 Publication by Source Titles

There is a departure from previous analyses. Elaish (2019) previously identified *Educational Technology and Society* as the top-ranked journal with 75 publications. According to Goksu (2021), *Computer and Education* ranked first with 103

publications. Nonetheless, Table 2 indicates that the most-active source title is *Lecture Notes in Computer Science*, including the sub-series *Lecture Notes in Artificial Intelligence* and *Lecture Notes in Bioinformatics*, with 112 publications, followed by the *International Journal of Mobile Learning and Organization* (90 publications) and *ACM International Conference Proceeding Series* (81 publications). The *Journal of Educational Technology and Society* is ranked fourteenth, with 24 publications, while *Computer and Education* is ranked seventh, with 47 publications between 2004 and 2020. The findings indicate that mobile-learning applications are still gaining traction in the field of computer science.

Table 2: Most-active source title

Source Title	TP	%	Publisher	Cite Score 2019	Cite Score 2020	SJR 2020	SNIP 2020
Lecture Notes in Computer Science Including Sub-series Lecture Notes in Artificial Intelligence and Lecture Notes In Bioinformatics	112	2.89%	Springer	1.9	1.8	0.249	0.628
International Journal of Mobile Learning and Organisation	90	2.32%	Inderscience	3.1	5.2	0.896	2.015
ACM International Conference Proceeding Series	81	2.09%	Association for Computing Machinery	N/A	N/A	N/A	N/A
International Journal of Interactive Mobile Technologies	72	1.86%	International Association of Online Engineering	3.1	2.9	0.316	1.417
Communications In Computer and Information Science	66	1.70%	Springer	0.7	0.8	0.16	0.32
Journal of Physics Conference Series	49	1.26%	IOP Publishing Ltd	0.7	0.7	0.21	0.464
Computers and Education	47	1.21%	Elsevier Ltd	13.4	14.4	3.026	4.411
International Journal of Mobile and Blended Learning	47	1.21%	IGI Global Publishing	1.9	1.9	0.225	0.409
Ceur Workshop Proceedings	45	1.16%	CEUR-WS.org	0.6	0.8	0.117	0.345
Advances In Intelligent Systems and Computing	41	1.06%	Springer Nature	0.9	N/A	N/A	0.428

4.1.3 Publication by Country

The ten most productive countries in terms of publications are shown in Table 3. Four Asian countries, including Malaysia, are ranked in the top ten (247 publications). China tops the list with 422 (10.89%) documents, followed by the United States with 358 (9.24%) and the United Kingdom with 284 (7.33%). China's dominance in publishing is not surprising, given the funding available to researchers, which results in papers that have frequently been cited with high research value, as well as with a consistent theme and clear direction of the research in areas, such as technical assistance, learning design, learning mode, and practices over the last decade (Zhang, 2020).

This finding is corroborated by Table 2, which lists the most frequently used source titles. For example, according to a further search of the Scopus database, a total of 112 articles for the proceedings have been contributed since 2003, and among the highest are *Lecture Notes in Computer Science,* including a sub-series of *Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics*. Between 2003 and 2020, this source contributed 72 articles.

During the study period, there were some countries, which produced less scholarly articles than others. Thus, this indicates an increase from three Asian-based institutions in the top ten countries in 2001 to 2010, to four Asian-based institutions in the top ten countries in 2011 to 2020. As a result, because mobile learning is linked inextricably to technological distribution, these developing countries, such as Taiwan, Malaysia, and Indonesia, can now be considered to have a relative technological advantage in education.

Table 3: Top 10 countries that contributed to the publications

Country	TP	NCP	TC	C/P	C/CP	*h*	*g*
China	422	241	1860	4.41	7.72	17	35
United States	358	269	6564	18.34	24.40	43	74
United Kingdom	284	229	6253	22.02	27.31	32	74
Taiwan	282	225	7191	25.50	31.96	42	80
Malaysia	247	169	1967	7.96	11.64	23	37
Indonesia	184	101	392	2.13	3.88	10	13
Australia	177	146	2412	13.63	16.52	23	44
Spain	163	134	1741	10.68	12.99	20	37
Germany	128	85	819	6.40	9.64	13	25
Canada	107	82	1239	11.58	15.11	17	33

4.1.4 The Subject Area

According to Table 4, the most frequently written subject in computer science during this period (2001–2020) was mobile learning (65.07%). The data demonstrate a consistent pattern, since Goksu's (2021) most recent bibliometric analyses in 2019. Elaish et al. (2019), conducted a bibliometric analysis between 1982 and 2015; and they discovered that 150 out of 500 articles in the top five journals publishing articles on mobile learning originated in the field of computer-science research. A two-decade analysis from 2001-2020 found an unusual change, in which computer science now accounts for 65% of mobile learning publications, followed by social science (47.5%), engineering (21.09%), and mathematics (8.01%).

This pattern demonstrates that mobile learning is gaining traction in computer science, as was previously evident in the literature. Increased research on educational tools, applications, approaches, design and development may account for computer-science research's predominance. This is due to the popularity of mobile devices, cell phones, smart-coaching systems and interactive learning environments that have been widely used in the past two decades (Goksu, 2021). Overall, this bibliometric analysis shows that computer science research seemed slow to recognise the advantages of mobile learning at the beginning of the millennium, thereby indicating the development of research applications.

Table 4: Subject area

Subject Area	**Total Publications (TP)**	**Percentage (%)**
Computer Science	2521	65.07
Social Sciences	1840	47.50
Engineering	817	21.09%
Mathematics	312	8.05%
Business, Management and Accounting	209	5.39%
Arts and Humanities	130	3.36%
Decision Sciences	129	3.33%
Medicine	96	2.48%
Psychology	89	2.30%
Physics and Astronomy	84	2.17%
Economics, Econometrics and Finance	58	1.50%
Energy	48	1.24%
Materials Science	47	1.21%

Environmental Science	41	1.06%
Health Professions	32	0.83%
Biochemistry, Genetics and Molecular Biology	19	0.49%
Nursing	15	0.39%
Agricultural and Biological Sciences	14	0.36%
Chemistry	14	0.36%
Earth and Planetary Sciences	12	0.31%
Multidisciplinary	12	0.31%
Chemical Engineering	11	0.28%
Pharmacology, Toxicology and Pharmaceutics	10	0.26%
Immunology and Microbiology	4	0.10%
Neuroscience	4	0.10%
Total	3874	100.00

4.2 Patterns of Citations in Mobile Learning

The purpose of RQ 2 is to ascertain the current citation pattern for the most influential publications on mobile learning in Scopus. Citation analysis is used to determine the impact of articles on mobile learning (Baker et al., 2020). Citation metrics for 3,874 articles obtained since approximately 4th May 2021, indicate an average of 1,978. Ten citations per year are required, with 39,574 citations reported to address RQ2, as in Table 5.

Table 5: Citation metrics

Metrics	**Data**
Papers	3874
Number of Citations	39562
Years	20
Citations per Year	1978.10
Citations per Paper	10.21
Cite_Authors	18342.73
Paper_Authors	1815.92
Authors'_Paper	2.79
h_index	87
g_index	140

(As illustrated in Figure 3, the most frequently cited source titles are conference proceedings and journals). A total of 61 source titles met these criteria, based on a minimum number of the source title's documents, of which the citations are equal to five.

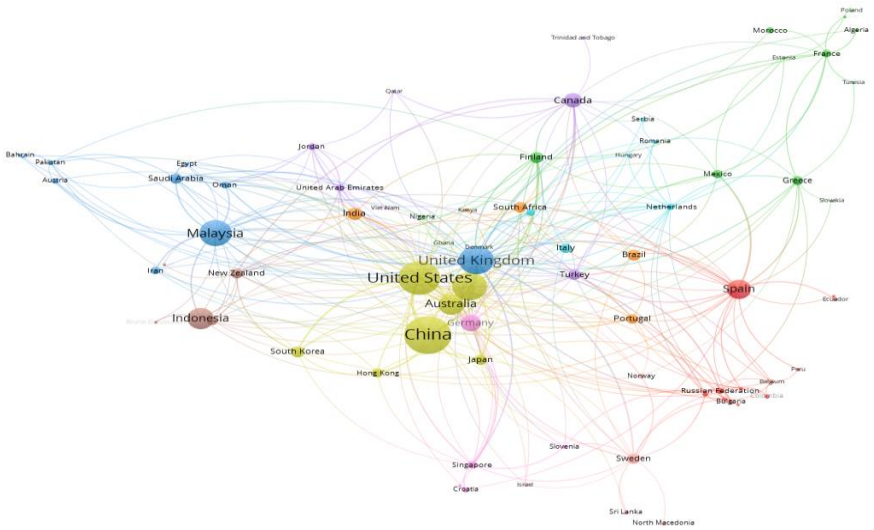

Figure 3: Visualisation of the citation network by country

Note: Minimum number of documents of an author = 5; Minimum number of citations of an author = 5

In addition to the data in Table 2, Figure 4 illustrates the most active source titles in mobile learning research, as measured by the number of documents produced. However, when the cite score of the most highly cited journal is examined, the following source titles (Table 2) rank in the top five: *Computers and Education* (14.4), *British Journal of Educational Technology* (7.6), *Educational Technology and Society* (7.2), *International Review of Research in Open and Distance Learning* (5.8), and *Education and Information Technologies* (5.8). (5.4).

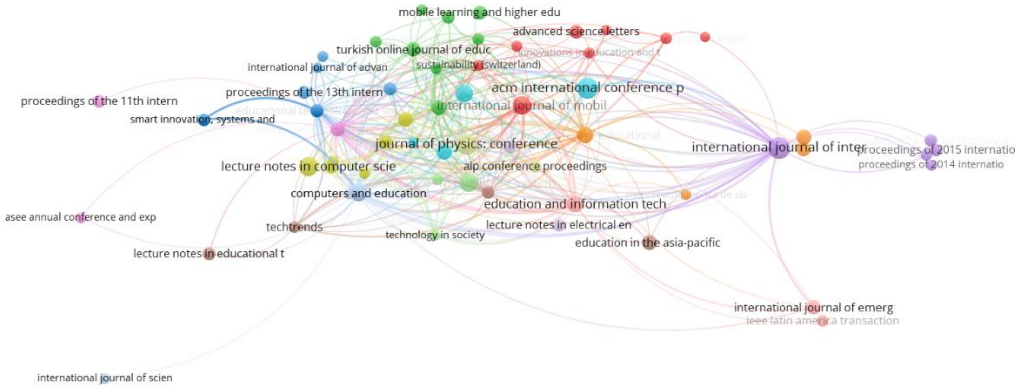

Figure 4: The citation by source network visualisation map

4.3 Themes in Research on Mobile Learning

To answer the third research question, which mobile learning theme is most popular among scholars? analysis of the co-occurrence of keywords and terms in the title and abstract data extracted from the Scopus database was performed. Accordingly, for two keywords to appear in the same article, it indicates that the two concepts share a great deal of common ground (Baker et al., 2020). To ensure that the author's keywords accurately describe the content of the article, co-occurrence and keywords were used (Comerio & Strozzi 2019).

4.3.1 Author's Keywords

Gonza'lez et al. (2018) assert that authors' keywords and their co-occurrence provide a complete picture of what occurs in a field of study. After removing duplicates caused by spelling differences, Table 6 shows the most popular author keywords during the first two decades of the millennium (e.g., m learning, m-learning). VOS-viewer was used in mapping all the keywords for each article, which included both author and index keywords, as illustrated in Figure 5. We examined the co-occurrence of each keyword that appears in this section at least five times. This threshold resulted in the discovery of 530 keywords. The strength of the relationship between the keywords is illustrated in Figure 5, which is represented by the size of the circle, the size of the font, the colour, and the thickness of the connecting line (Sweileh et al., 2017).

Table 6: Top used keywords

Author Keywords	Total Publications (TP)	Percentage (%)
Mobile Learning	2212	57.07%
E-learning	1624	41.90%
Students	737	19.01%
Learning Systems	711	18.34%
M-Learning	665	17.16%
Education	640	16.51%
Mobile Devices	623	16.07%
M-learning	540	13.93%
Teaching	491	12.67%
Computer-Aided Instruction	424	10.94%
Engineering Education	412	10.63%
Mobile Technology	282	7.28%
Higher Education	222	5.73%
Surveys	190	4.90%
Mobile-learning System	189	4.88%
Mobile Telecommunication Systems	176	4.54%
Education Computing	175	4.51%
Telecommunication Equipment	175	4.51%

Curricula	173	4.46%
Mobile Applications	171	4.41%

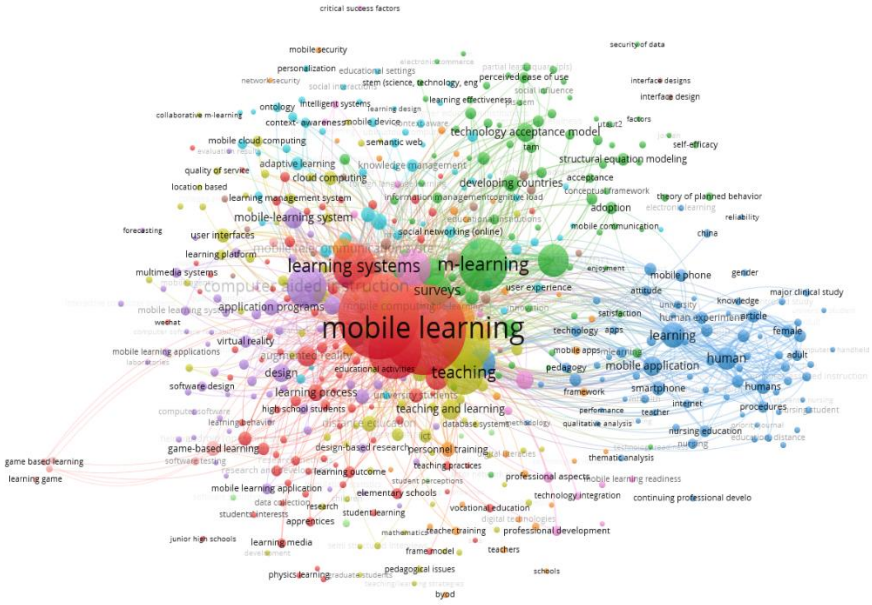

Figure 5: Network visualisation map of all the keywords

As illustrated in Figure 5, the terms mobile learning, learning system, augmented reality, surveys, learning outcomes, learning process and game-based learning are frequently used interchangeably; since they are closely related, and frequently occur in conjunction with each other. A different colour represents each of the eleven clusters identified in this visualisation map in this figure. Six clusters contain a top cluster containing at least 50 items. The top three clusters contain 87 items (red) on mobile learning, 83 items (green) on m-learning, and 80 items (blue) on human learning. This cluster demonstrates that human studies of mobile learning and m-learning have been conducted, particularly in computer science. This map is also demonstrated by three additional clusters, demonstrating that this field also focuses on education, a teaching aid. That is, 72 educational items (yellow-green), 61 computer-aided instruction items (purple), and 58 computer-aided instruction items (sky blue).

4.3.2 Title and Abstract

This study examined the phrase co-occurrence network using the title and abstract fields. In this configuration, 61 words met the threshold. However, a relevance score was generated for each of the 61 terms, choosing the most acceptable score. The 60% most acceptable terms have been chosen by using the default setting. As a result, the number of terms chosen was 3,502, the VOS-viewer software's default value, as illustrated in Figure 6. This visualisation map resulted in the creation of a map of these terms' co-occurrences. The distance between nodes represents the relationship between phrases or concepts in this network visualisation, whereas the nodes themselves represent the terms or concepts (Sedighi ,2016). Each colour in this illustration represents a different phase. As a result, the map will contain

six clusters representing six distinct themes. This map depicts six themes: (red) e-learning (55 items), (green) mobile learning (28 items), (blue) education (26 items), (yellow/green) students (26 items), (purple) information and communication (16 items), and (sky-blue) teaching group (14 items).

This cluster demonstrates that the theme of writing in mobile learning is focused on education, which incorporates e-learning into its teaching and learning processes.

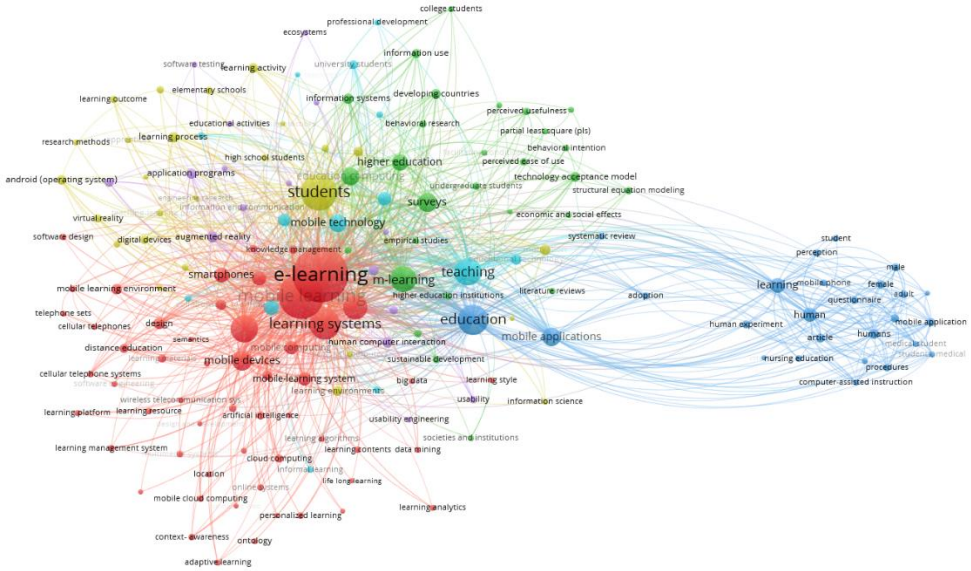

Figure 6: Network visualisation using the title and abstract field of a phrase co-occurrence in VOS-viewer (Full Counting)

5. Discussion

This section elaborates on prior findings by responding to the research questions.

RQ1: What has been the recent trend in mobile learning publications?

This bibliometric analysis of publications published between 2001 and early 2020 is timely; because it quantifies the extent to which the trend towards mobile-learning applications has persisted over the first two decades of the twenty-first century; and it will probably continue into the next two decades. The pattern of publication of mobile-learning strategies/approaches that go up and down, according to the current situation, will continue to attract more practitioners, researchers and scholars in the coming decade, in which the use of mobile learning will surely continue. Moreover, the analysis shows a high level of involvement by developing countries, especially Asian countries, in this type of research.

Guksu (2021) discovered that Asian countries were the most active in mobile-learning research between 2015 and 2019. As this study demonstrates, the results of two decades of research from developing countries run consistently with justifiable gaps; and they indicate the improvement of educational technology in these developing countries since the beginning of the millennium.

According to the tables and data in the preceeding sections, mobile learning appears likely to be widespread in the future. The advancement of technology-based education has proven to be an excellent option, especially at difficult times when synchronous learning with face-to-face physical teaching and learning sessions are unavailable, or considered to be impractical. Hence, it increases security by customising digital educational materials, based on the student's learning style and the device's requirements (Vallejo-Correa et al., 2021). This has implications for researchers in the field of education to ensure that the use of mobile learning is a necessity for online learning where most students are more into the use of the mobile devices, and the learning styles are more into audio, visual, and hands-on, which is video.

Indeed, the current COVID-19 epidemic, for example, has prompted worldwide requests for emergency remote teaching and learning instruction. Therefore, educators need to sharpen their competencies and expand their understanding of mobile learning and its integration into the process of incorporating technology into their educational methods for today's digital natives (Rajendran & Yunus, 2021).

RQ2: What is the current citation pattern for mobile learning publications?

To date, 39,562 citations have been obtained from 3,874 documents, representing a total of 1,978.10 citations per year, 10.21 citations per paper, 1,815.92 papers per author, and 2.79 authors per paper. In addition, only 1,213 out of 3,874 documents have been cited so far. Mobile-learning studies have also achieved a 47 h-index and a 140 g-index at the time when these data were analysed. This analysis guides journal publishers to see whether publications in the Scopus database provide many citations to authors. Moreover, this analysis also provides a guideline that the publication of articles has a high allocation for acquisitional budget-breakdown (Bowman, 1991).

Publishers need to ensure that published articles cite those articles that have been published by the journal, so that the number of citations would increase on the Scopus-database platform.

RQ3: Which mobile learning topics are most popular among scholars?

Based on the analysis of all the keywords, this study identified eleven themes, including mobile learning, m-learning, human, education, computer-assisted instructions, human interaction, mobile-technology interactions, intelligence-system games, and engagement. Nevertheless, this visualisation map contains six clusters, based on terms occurrences in the title and abstract of Scopus articles. These themes were classified as follows: e-learning was assigned as theme one; m-learning was assigned as theme two; education was assigned as theme three; students were assigned as theme four, information and communication were assigned as theme five, and teaching was assigned as theme six. Consequently, these issues appear to be central in mobile-learning research.

RQ4: What areas of mobile learning require additional research?

As stated in the previous sections, at the turn of the second millennium, the global use of mobile phones increased, due to the COVID-19 pandemic, which resulted in the Movement Control Order (MCO). This MCO will profoundly affect the education systems in developing countries, and the least developed and emerging countries, in which most teaching and learning occur online (Hofer et al., 2021). Most teaching materials are uploaded online and implemented by using blended learning, flipped learning, and online-learning methods. There are no issues with internet connectivity, bandwidth, or ICT equipment in most developing and high-income countries.

However, students in the least developed low-income countries typically only have access to a telecommunication device, such as a mobile phone, which relies on mobile data to assist those with limited internet capacity. The use of social media and apps, such as Facebook, Instagram, Twitter, WhatsApp, WeChat, telegram, and game-based learning apps has enabled students to self-regulate their learning by uploading learning materials to an online platform by using their own, or their parents', mobile device, thereby enabling teachers to teach remotely from home via asynchronous learning by using videos.

However, because mobile learning focuses on the device, apps, and learning approach, there is concern about how interactions, engagement, motivation and critical thinking occur during online synchronous and asynchronous learning (Har et al., 2019; Thomas, 2020; Al-Shamsi et al., 2020). As a result of this concern, various instructional designs have emerged that are appropriate for the device, apps, and for the learning approach used. For instance, how to create lesson plans appropriate for online synchronous and asynchronous learning via mobile devices, apps and platforms. The future study will concentrate on the use of mobile applications by most students, who only have access to a mobile phone and mobile data, when they are learning online.

The lesson-plan design and mobile-application development of these teaching materials should consider students' interaction and engagement with teachers and teaching materials (Purarjomandlangrudi & Chen, 2020). This situation demonstrates the critical need for continuous professional development programmes, to which all educators must adhere, in order to ensure that all students receive an adequate education during this critical period (Lowenthal, 2020). The end of the pandemic is unknown. Beyond the existing applications, there is still considerable room for growth in game-based learning, learning algorithms, learning technologies, software prototyping, interface design, data security, online coaching, online facilitation, and online feedback. By identifying and exploring these approaches, this argument implies that diversifying mobile learning approaches are a real possibility.

6. Conclusion

The purpose of this study was to examine the pattern of mobile-learning research, the pattern of citations, and the visualisation of the theme, and to make

recommendations for future research directions in mobile learning. The data were gathered via keyword searches for "m-learning" and "mobile learning" with the data extracted directly beneath the "title of the article". Additional research in other areas, such as "abstracts and keywords", should be conducted, which will require further screening and filtering of the dataset. As a result, the teachers and educators identified can change pedagogy, in order to cope with the evolution of educational technology that uses mobile-learning applications.

The findings of this study will assist academics in gaining a better understanding of the global impact of mobile learning. Mobile learning is expected to continue to gain popularity over the next few decades, because of the online-learning applications that have increased students' engagement and closed the accessibility gap. This popularity demonstrates the critical role of online learning. Furthermore, in addition to technological advancements that have accelerated many people's adoption of mobile learning, the rise of an electronic-data security threat, due to electronic accessibility, has actively contributed to many instructors and students being placed in dangerous situations.

For example, the use of mobile-learning approaches and cyber threats in various domains of education highlights the risk associated with the collection of students' and educators' data over time. When users signed up for specific applications for web-based online learning resources and completed their profiles on a digital platform, they exposed themselves to cyber risk. As a result, it is a subject that requires additional attention from scholars and practitioners involved in developing lessons and mobile-learning applications. Thus, this new line of research should result in a more-advanced visualisation of mobile-learning patterns in the coming decade.

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