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GLOBAL TRENDS IN MOBILE LEARNING RESEARCH FOR EDUCATION: A BIBLIOMETRIC ANALYSIS

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Abstract:

Mobile Learning (m-Learning) has transformed education by providing accessibility, flexibility, and new learning approaches in a variety of situations. Despite its expanding importance, a thorough grasp of research trends, collaborations, and thematic focus is required to discover advancements and shortcomings in this discipline. This study employs bibliometric analysis to investigate the evolution of "Mobile Learning in Education" using data pulled from the Scopus database. A total of 1,162 publications were analysed using Scopus Analyser and VOSviewer software to map research trends, network collaborations, and topic clusters. The findings show a tremendous rise in m-Learning research over the last two decades, with China and the United States emerging as the primary contributors. Keyword co-occurrence analysis revealed themes such as "mobile learning," "e-learning," "student engagement," and "emerging technologies," which reflect the incorporation of novel methodologies such as augmented reality and gamification into m-Learning. Despite these developments, gaps remain in terms of content quality, inclusivity for marginalised groups, and the long-term impact of m-Learning efforts. The study also identified infrastructure constraints and differences in global adoption rates, particularly in developing countries. The findings emphasise the importance of multidisciplinary frameworks, localised research, and longitudinal studies in improving the scalability and effectiveness of m-Learning. This bibliometric analysis provides useful insights for educators, researchers, and policymakers, offering a thorough overview of the field's evolution and a strategic direction for future research and application in education systems worldwide.

Keywords:

Education, Mobile Learning, Technology, Trends

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Introduction

Mobile Learning (m-Learning) has emerged as a game changer in education, using the broad availability of mobile devices to improve teaching and learning processes. The growing availability of smartphones and tablets, which offer flexible, personalised, and context-aware learning experiences, has increased the use of mobile technologies in educational settings (Naveed et al., 2023; Lázaro & Duart, 2023). m-Learning has had a huge impact on higher education, allowing for the creation of multimodal learning environments that blend formal and informal educational contexts (Pimmer et al., 2016). The COVID-19 pandemic has accelerated the adoption of m-Learning tools, emphasising their ability to support remote education and provide educational continuity during disruptions (Lázaro & Duart, 2023).

m-Learning has many theoretical underpinnings, including behaviourism, constructivism, cognitivism, and socio-cultural theories (Naveed et al., 2023). These theories drive m-Learning implementation by emphasising several aspects of the learning process, such as interaction, collaboration, and context awareness (Naveed et al., 2023; Bai, 2019). Research indicates that m-Learning can improve student engagement, motivation, and learning outcomes through interactive and multimedia-rich educational content (García-Martínez et al., 2019; Seppälä & Alamäki, 2003). Furthermore, m-Learning applications have been utilised to support a variety of educational methods, such as game-based learning, inquiry-based learning, and personalised learning (Bai, 2019).

Despite the potential benefits, the widespread implementation of m-Learning in higher education confronts hurdles. The evidence for widespread adoption is currently limited, and many m-Learning projects use instructional methodologies that may not fully realise mobile technologies' revolutionary potential (Pimmer et al., 2016). However, increased access to digital mobile media provides unprecedented opportunities to enhance traditional educational methods and promote lifelong learning (Pimmer et al., 2016; Lim & Churchill, 2016). Future research should address identified gaps in the literature, investigate innovative pedagogical models, and develop empirically validated recommendations to inform the effective integration of m-Learning in educational settings (Naveed et al., 2023; Goundar & Kumar, 2021; Tang et al., 2023).

Literature Review

m-Learning has developed as a disruptive educational paradigm, using the widespread availability of mobile devices to enable flexible, accessible, and context-sensitive learning experiences. Md Osman & Md Napeah (2021) undertook a bibliometric examination of 3,874 papers to demonstrate m-Learning's inclusion into worldwide educational systems. Their research found a solid correlation between "e-learning" and "m-Learning" concepts, establishing China as a pioneer in the field. Complementary findings from Castillo-Manzano et al. (2017) revealed a low level of mobile device integration in economics education, emphasising the need for strategic frameworks to enhance uptake. Similarly, Alturki and Blanchfield (2018) enhanced the discussion by creating a conceptual framework customised to Kuwaiti higher education that addressed cultural and infrastructure limitations. m-Learning has shown a great deal of promise in improving training results in professional and technical education. This was demonstrated by Windisch et al. (2019) using the "Head to Toe" medical education program, which demonstrated its scalability from student training to clinical use. Similarly, an m-Learning program based on instructional design principles showed gains in nursing students' clinical competence (Kim & Im, 2024). According to Abdullah et al. (2021),

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competency-based components are essential for m-Learning frameworks in technical education, and specialised methods catered to certain professional settings can optimise efficacy.

Emerging technologies like augmented reality and gamification have expanded the scope of m-Learning (Fombona et al., 2017). Fombona et al. (2017) investigated the educational usefulness of augmented reality, focusing on its motivating effects and ability to build dynamic learning environments. Sinchiguano et al. (2022) reported on the effectiveness of a gamified mobile application in improving mathematics skills among high school pupils, emphasising the value of interactive and engaging techniques. Similarly, Calleja et al. (2019) highlighted the benefits of blended learning applications in preschool education, focusing on usability and stakeholder adoption. These findings highlight the need to incorporate modern technologies into m-Learning frameworks in order to maintain student interest and improve learning results. Even with these developments, a number of issues still exist. The obstacles noted by Kala et al. (2022), such as inadequate devices and network restrictions, highlight the infrastructure limitations of m-Learning, especially in areas that depend on 4G technology. The viability of adopting m-Learning for independent study in mathematics was questioned by Phuong Thao et al. (2019) because of the poor quality of the content and the disinterest of the students. These results demonstrate how urgently better content standards and infrastructure improvements are needed to remove these obstacles.

The social and cultural aspects of m-Learning adoption are equally important. Reddy et al. (2017) discovered that Pacific students had moderate ICT competencies, indicating that they are ready for m-Learning integration but also require basic digital skills training. Yépez-Reyes (2018) investigated the relationship between formal and informal learning in Ecuador, focusing on the potential of blended learning techniques to promote accessible and cooperative educational environments. These findings highlight the necessity of culturally appropriate implementation strategies for m-Learning uptake. Furthermore, studies by Geetha and Senthamizh Pavai (2019) and De Oliveira et al. (2020) show that m-Learning has the ability to overcome accessibility and inclusion concerns. Geetha and Senthamizh Pavai (2019) emphasised the need for parents and educators to guide children's mobile phone usage to reduce mental health consequences. De Oliveira et al. (2020) emphasised the necessity for user-centric designs that support a variety of learner demographics while concentrating on developing accessible m-Learning applications for the elderly. Similarly, Yin Ling et al. (2018) showed that although access and engagement issues still exist, working adults see m-Learning favourably because of its flexibility.

Despite a large body of research, many significant gaps limit m-Learning's potential as a transformational educational tool. One important gap exists between content creation and pedagogical alignment. Phuong Thao et al. (2019) and Sinchiguano et al. (2022) highlighted the scarcity of high-quality, context-specific content adapted to diverse fields, notably STEM education. These findings indicate the need for more studies to develop discipline-specific information consistent with educational objectives. The availability and quality of technological infrastructure continue to pose substantial issues. Kala et al. (2022) and Abdullah et al. (2021) identified constraints in existing networks and devices as important impediments. To overcome these constraints and guarantee dependable m-Learning experiences, the shift to cutting-edge technologies like 5G and cloud computing is essential. Another crucial aspect that needs consideration is user engagement and behavioural issues. The adoption of m-Learning is

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influenced by behavioural and psychological aspects, as noted by Ebardo & Suarez (2023) and Reddy et al. (2017). To maintain engagement, more studies on gamification techniques and adaptive learning systems are still required.

Additionally, as mentioned by De Oliveira et al. (2020) and Yin Ling et al. (2018), there are still issues with accessibility and inclusivity, especially for working adults, older students, and people in low-resource environments. Although new technologies like gamification and augmented reality have shown promise, little is known about how they may be integrated with m-learning (Lampropoulos et al., 2022; Claros-Perdomo et al., 2022). Calleja et al. (2019), Smiderle et al. (2020), and Lampropoulos and Sidiropoulos (2024) suggested longitudinal research to evaluate the long-term effects of these technologies on engagement and learning outcomes. Although new technologies like gamification and augmented reality have shown promise, little is known about how they may be integrated with m-learning (Claros-Perdomo et al., 2022; Lampropoulos et al., 2022). (Calleja et al., 2019; Lampropoulos & Sidiropoulos, 2024; Smiderle et al., 2020) suggested longitudinal research to evaluate the long-term effects of these technologies on engagement and learning outcomes. In a similar vein, Md. Osman and Md. Napeah (2021) and Alturki and Blanchfield (2018) emphasised the necessity of context-specific frameworks to modify m-Learning tactics to various cultural and economic contexts.

Last but not least, the majority of existing m-Learning research focuses on immediate outcomes, leaving a knowledge gap about its long-term implications on skill development and academic achievement. Kim and Im (2024) demonstrated that nursing students' clinical competence improved immediately, but these improvements must be substantiated through long-term assessments. Grant (2019) underlined the need for longitudinal research in evaluating the efficacy of m-Learning contexts. m-Learning has altered education by providing previously unheard-of levels of accessibility and flexibility. Nonetheless, significant gaps remain in research methodology, user engagement, infrastructure, inclusivity, and content development. Although studies by Windisch et al. (2019), Md. Osman & Md. Napeah (2021) and others offer a strong basis. Future research needs to concentrate on inclusive frameworks.

Research Questions

1.0 How do the research trends in mobile learning evolve over time based on publication years?
2.0 Which authors have made the most significant contributions to m-Learning research, and what is their publication output?
3.0 What is the distribution of document types in m-Learning research, categorised by subject area?
4.0 Who are the top 10 most-cited authors in the field of m-Learning research?
5.0 What are the distribution patterns and trends of keywords used in mobile learning research?
6.0 How do countries collaborate in mobile learning research through co-authorship?

Methodology

Bibliometrics is the collection, organisation, and analysis of bibliographic data produced from scientific publications (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). This method employs general descriptive statistics such as publishing journals, publication years, and major author classification (Wu & Wu, 2017), as well as more sophisticated techniques such as document co-citation analysis. To develop a thorough bibliography and generate trustworthy results, a successful literature review must be conducted iteratively, which includes identifying appropriate keywords, conducting literature searches, and conducting in-depth

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analysis (Fahimnia et al., 2015). In keeping with this, the study concentrated on high-quality papers, which provide significant insights into the theoretical viewpoints guiding the research field's evolution.

Scopus was used for data collecting in order to guarantee data reliability (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017). Additionally, we limited the selection to articles published in rigorously peer-reviewed journals, excluding books and lecture notes, in order to include only high-quality publications (Gu et al., 2019). Interestingly, Elsevier's Scopus, which is renowned for its extensive coverage, made it possible to gather publications for this research from 2020 to November 2024.

Data Search Strategy

Advanced searching on the Scopus database allows researchers to perform precise and tailored searches using Boolean operators (AND, OR, NOT), field-specific codes (e.g., author, title, abstract), and other techniques like wildcard characters and proximity operators. This allows for a more precise search using specific criteria like publication year, document type, and journal name. Advanced search also includes filters for narrowing down results by language, subject area, and access type, making it particularly useful for systematic reviews and bibliometric studies. Using these approaches, refinement selected 1162 articles for bibliometric analysis. As of November 2024, the study included all publications from the Scopus database about m-Learning, emphasising education.

Table 1: The Search String

Scopus	**TITLE-ABS-KEY ("mobile learning" OR "m-Learning" AND education) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2024)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English"))**

Table 2: The Selection Criterion For Searching

Criterion	**Inclusion**	**Exclusion**
Language	English	Non-English
Timeline	2020 – 2024	< 2020
Literature type	Journal (Article)	Book, Review, Proceeding

Data Analysis

VOSviewer, developed by Nees Jan van Eck and Ludo Waltman at Leiden University in the Netherlands (van Eck & Waltman, 2010, 2017), is a user-friendly bibliometric program that many researchers use to see and analyse scientific literature. It is especially excellent for building intuitive network visualisations, clustering related items, and producing density maps,

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which make it easier to investigate co-authorship, co-citation, and keyword co-occurrence networks. This flexibility enables researchers to get a thorough understanding of research environments. VOSviewer's interactive interface and regular updates allow for rapid study of big datasets. At the same time, its ability to compute metrics, customise visualisations, and integrate diverse bibliometric data sources makes it an invaluable tool for investigating difficult research subjects.

VOSviewer's most notable feature is its ability to convert complex bibliometric statistics into clear visual maps and charts. VOSviewer, which specialises in network visualisation, excels in clustering related items, analysing keyword co-occurrence patterns, and generating density maps, making it easy for rookie and experienced researchers to navigate study landscapes. With continued development, VOSviewer provides cutting-edge bibliometric analysis, delivering deep insights via metrics computation and customisable visualisations. Its adaptability to many types of bibliometric data, such as co-authorship and citation networks, makes it an indispensable tool for scholars seeking deeper insights into their subjects.

For this analysis, datasets with information on publication year, title, author name, journal, citation counts, and keywords (in PlainText format) were obtained from the Scopus database, covering the period from 2020 to November 2024. These datasets were then analysed using VOSviewer software version 1.6.19, employing VOS clustering and mapping techniques to create visual maps. Offering an alternative to Multidimensional Scaling (MDS), VOSviewer situates items within a low-dimensional space so that the proximity between items accurately reflects their relatedness (van Eck & Waltman, 2010). In this way, VOSviewer's approach is similar to MDS [38]. Datasets containing information on publication year, title, author name, journal, citation counts, and keywords (in PlainText format) were gathered from the Scopus database between 2020 and November 2024. These datasets were then analysed with VOSviewer version 1.6.19, which used VOS clustering and mapping techniques to generate visual maps.

VOSviewer, an alternative to MDS, position things in a low-dimensional space so that their closeness appropriately reflects their relatedness (van Eck & Waltman, 2010). In this regard, VOSviewer's approach is comparable to MDS [38]. Unlike MDS, which primarily computes similarity metrics such as cosine and Jaccard indices, VOS uses a more suitable method for normalising co-occurrence frequencies, such as the Association Strength (AS_{ij}), which is derived as the following (Van Eck & Waltman, 2007):

$$AS_{ij} = \frac{C_{ij}}{W_i W_j}$$

This quantity is "proportional to the ratio between, on the one hand, the observed number of co-occurrences of *i* and *j* and, on the other hand, the expected number of co-occurrences of *i* and *j* under the assumption that co-occurrences of *i* and *j* are statistically independent" (Van Eck and Waltman, 2007.)

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Findings and Discussion

How Do The Research Trends In M-Learning Evolve Over Time Based On Publication Years?

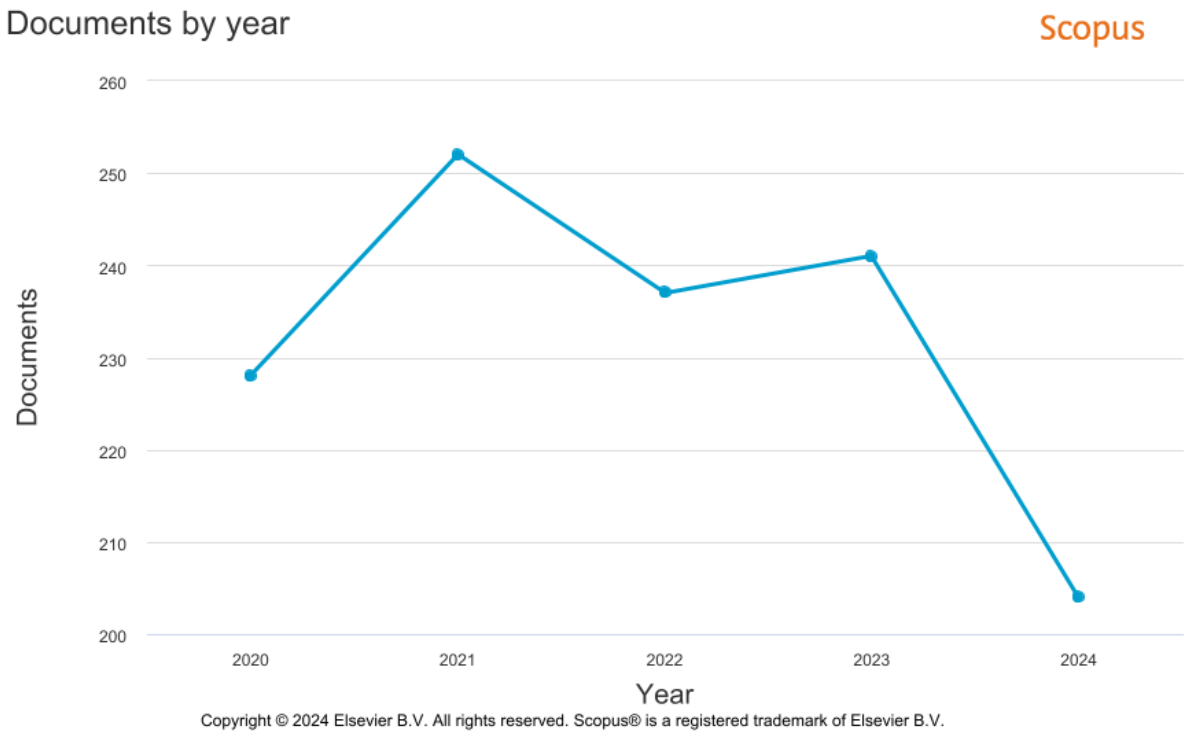

Figure 1: Publication of m-Learning Research According To Years.

The publication pattern in m-Learning research from 2020 to 2024 shows an initial boom followed by a substantial fall, indicating a speedy response to the COVID-19 outbreak and a subsequent shift in research objectives. In 2020, nearly 230 documents were published, representing a significant rise as educational institutions globally sought mobile solutions to promote remote learning. The pandemic prompted an unprecedented demand for m-Learning research to address pressing issues like accessibility, engagement, and effective pedagogy in virtual contexts. This urgency resulted in a peak of roughly 255 papers in 2021, as academics focused on optimising m-Learning applications, examining frameworks such as TPACK and SAMR, and researching new pedagogical models to improve digital learning outcomes. The high publication rate during this time period demonstrates a concerted attempt to incorporate m-Learning solutions as part of a long-term, sustainable educational strategy.

However, starting in 2022, the pattern suggests a progressive fall in publications, culminating in a major drop to around 210 documents in 2024. This decline could imply that the intensive phase of exploratory research in m-Learning has given way to more stable, refined applications. With pandemic-related demands reduced, researchers may now be able to focus on consolidating discoveries, evaluating the usefulness of m-Learning models, and integrating these models with other developing technologies, such as Artificial Intelligence (AI) and adaptive learning systems. The dramatic decline in 2024 implies that, while m-Learning is still

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relevant, the area is maturing, with a tighter focus on refining existing applications rather than developing new ones. This move may also represent a larger trend in the education technology sector, with a growing interest in hybrid learning models and personalised learning tools that integrate mobile technology with in-person and AI-supported instruction.

Which Authors Have Made The Most Significant Contributions To Mobile Learning Research, And What Is Their Publication Output?

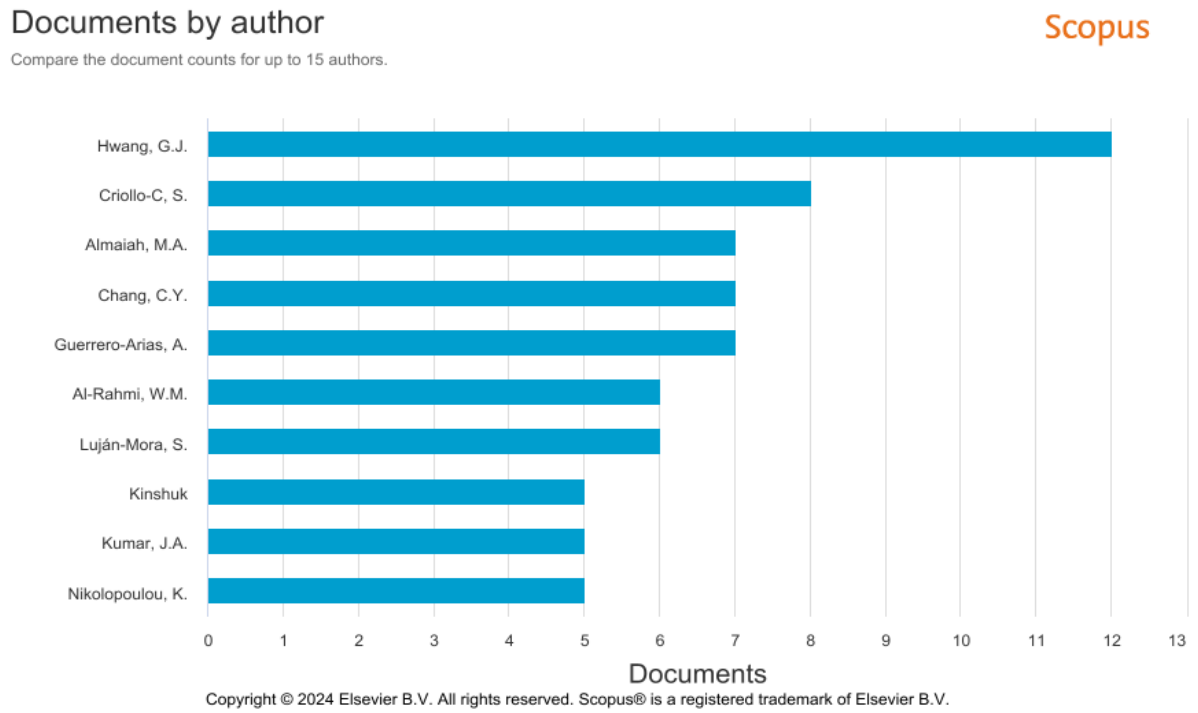

Figure 2: Publication on m-Learning According To Authors.

The analysis of the top authors contributing to m-Learning research gives important information about prominent influences and active researchers in this field. Among the mentioned writers, Hwang, G.J. has the most publications, totalling around 12 documents. Hwang's prominent position demonstrates a significant commitment to promoting m-Learning, most likely through a range of study topics such as mobile-assisted learning, personalised education via technology, and instructional design that uses mobile platforms. This degree of activity demonstrates Hwang's importance in influencing and steering the m-Learning discourse, providing basic studies on which other researchers can build.

Following Hwang, Criollo-C, S., and Almaiah, M.A., each has a significant number of publications indicating active involvement in m-Learning research, albeit with slightly less than Hwang. Criollo-C and Almaiah's research contributions are anticipated to focus on several aspects of m-Learning, such as educational frameworks, technological integration, and assessing m-Learning's effectiveness across multiple educational contexts. Other authors, such as Chang, C.Y., Guerrero-Arias, A., and Al-Rahmi, W.M., produce significant output, each submitting five to six documents. Their consistent publishing record demonstrates a dedication

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to researching and understanding the function of m-Learning in education, with the expectation of adding varied viewpoints and findings that benefit the field as a whole.

The presence of authors such as Luján-Mora, S., Kinshuk, Kumar, J.A., and Nikolopoulou, K. demonstrates a multidisciplinary interest in m-Learning research, as each author contributed five documents. This group of authors most likely has competence in educational technology, digital pedagogy, and cross-cultural studies, demonstrating the field's interdisciplinary nature. Their contributions help address the problems and potential of m-Learning in various educational settings, ranging from primary to higher education. This mix of prolific authors emphasises the collaborative aspect of m-Learning research, in which specialists from varied backgrounds collaborate to develop a thorough understanding of mobile learning's promise and limitations in educational environments worldwide.

Table 3: Publication on m-Learning According To Authors

Author Name	Number of Document	Percentage (%
Hwang, G.J.	12	1.032
Criollo-C, S.	8	0.688
Almaiah, M.A.	7	0.602
Chang, C.Y.	7	0.602
Guerrero-Arias, A.	7	0.602
Al-Rahmi, W.M.	6	0.516
Luján-Mora, S.	6	0.516
Kinshuk	5	0.430
Kumar, J.A.	5	0.430
Nikolopoulou, K.	5	0.430

What Is The Distribution Of Document types in m-Learning Research, Categorised By Subject Area?

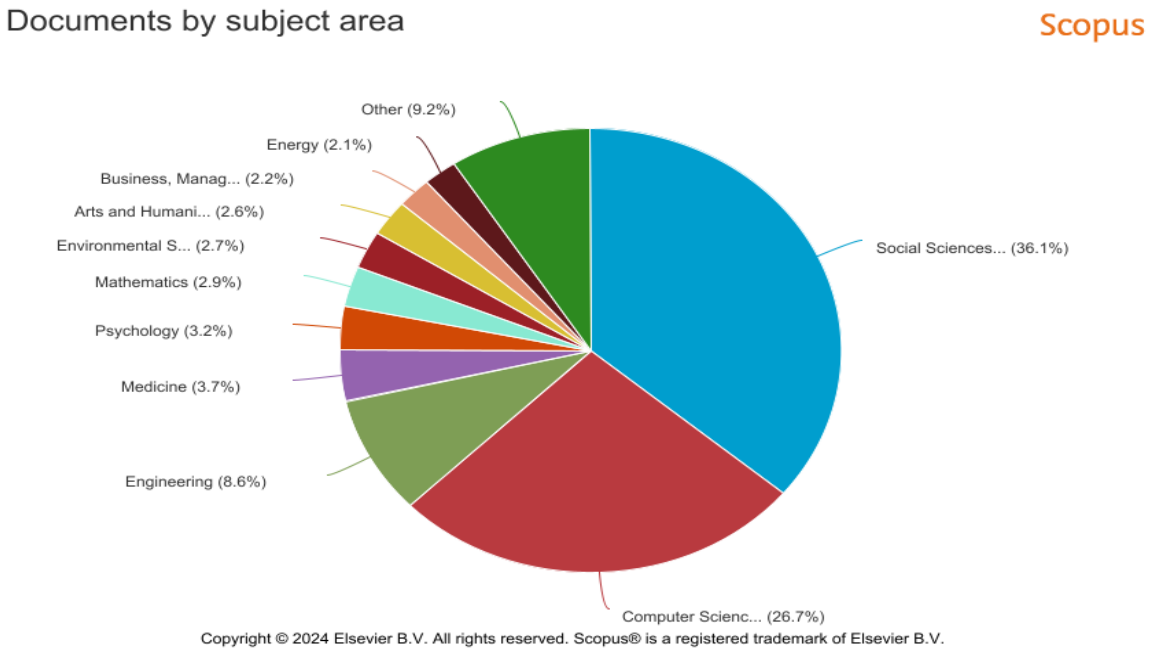

Figure 3: Publication on m-Learning According To Research Areas.

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A significant focus on the social sciences is evident in the subject distribution of m-Learning research, accounting for 36.1% of publications. This dominance demonstrates the field's emphasis on comprehending how m-Learning affects society, behaviour, and education. Social science researchers probably look into how mobile technology affects educational access, engagement, and learning results. Studies on ethical issues, digital citizenship, and the wider societal ramifications of using mobile devices in classrooms are also included in this field. The significant emphasis on social sciences indicates m-Learning's interdisciplinary character, which transcends technology to address human-centred elements essential to successful educational transformation.

With a substantial share of 26.7%, computer science comes in second to social sciences, highlighting the contribution of technological advancement to m-Learning. In order to improve usability, usefulness, and adaptability, research in this area probably focuses on software applications, platform design, and technological aspects of m-Learning environments. Engineering contributes to the structural and design elements of mobile devices and network systems, making up 8.6% of this technological backbone. Furthermore, professions like psychology (3.2%) and medicine (3.7%) demonstrate how m-Learning is used in specialised disciplines, which helps with professional training and comprehension of cognitive impacts. When taken as a whole, these topics highlight the flexible and multidisciplinary nature of m-Learning research, indicating its potential influence on a range of domains and educational levels.

Who Are The Top 10 Most-Cited Authors In The Field Of Mobile Learning Research?

Table 4: Most-Cited Authors in m-Learning.

Authors	Title	Year	Journal	Cited by
(Troussas et al., 2020)	Collaboration and fuzzy-modeled personalisation for mobile game-based learning in higher education	2020	Computers and Education	187
(Díaz et al., 2020)	Virtual world as a resource for hybrid education	2020	International Journal of Emerging Technologies in Learning	175
(Rahiem, 2020)	The emergency remote learning experience of university students in Indonesia amidst the COVID-19 crisis	2020	International Journal of Learning, Teaching and Educational Research	147
(Hoi, 2020)	Understanding higher education learners' acceptance and use of mobile devices for language learning: A Rasch-based path modelling approach	2020	Computers and Education	147

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(Criollo-C et al., 2021)	Mobile learning technologies for education: Benefits and pending issues	2021	Applied Sciences (Switzerland)	140
(López-Faican & Jaen, 2020)	EmoFindAR: Evaluation of a mobile multiplayer augmented reality game for primary school children	2020	Computers and Education	130
(Akour et al., 2021)	Using machine learning algorithms to predict people's intention to use mobile learning platforms during the COVID-19 pandemic: Machine learning approach	2021	JMIR Medical Education	123
(Soltani & Morice, 2020)	Augmented reality tools for sports education and training	2020	Computers and Education	122
(Moro et al., 2021)	HoloLens and mobile augmented reality in medical and health science education: A randomised controlled trial	2021	British Journal of Educational Technology	121
(Escamilla-Fajardo et al., 2021)	Incorporating TikTok in higher education: Pedagogical perspectives from a corporal expression sport sciences course	2021	Journal of Hospitality, Leisure, Sport and Tourism Education	109

The top 10 authors with the most citations in m-Learning research from 2020 to 2021 have published notable studies on a variety of topics, ranging from emergency remote learning to augmented reality applications. Troussas et al. (2020) have received 187 citations for their research on personalised mobile game-based learning in higher education, emphasising the need for collaboration and adaptability in m-Learning settings. Díaz et al. (2020) have 175 citations and focus on the use of virtual worlds as resources for hybrid education. This study is relevant as institutions adapt to online and blended learning formats. Rahiem (2020) and Hoi (2020) each obtained 147 citations for their research on the adoption and problems of m-Learning during the pandemic.

Rahiem's (2020) research on emergency remote learning experiences among Indonesian university students highlights the immediate challenges encountered during the crisis. Hoi (2020) investigated mobile device acceptance for language learning in higher education, providing insights into the factors influencing technology adoption. Furthermore, Criollo-C et al. (2021), with 140 citations, investigated the benefits and problems of m-Learning technologies, providing a complete review of mobile learning's advantages and pressing issues. Other highly cited writers studied the integration of augmented reality and machine learning in m-Learning. López-Faican & Jaen (2020), with 130 citations, investigated the usefulness of an AR-based multiplayer game for primary school children, whereas Akour et al. (2021), with 123 citations, used machine learning methods to anticipate users' intentions to use m-Learning

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platforms. Soltani and Morice (2020) also made contributions to AR research, with an emphasis on sports education (122 citations), demonstrating the adaptability of m-Learning in various educational disciplines.

Finally, Moro et al. (2021) and Escamilla-Fajardo et al. (2021) garnered 121 and 109 citations, respectively. Moro et al. (2021) studied the use of HoloLens and mobile AR in medical education, demonstrating AR's potential in professional training. On the other hand, Escamilla-Faja et al. (2021) integrated TikTok into higher education, demonstrating the importance of social media as a pedagogical tool. These highly referenced publications highlight a wide range of techniques, from remote learning adaptations to interactive technologies in education, demonstrating the dynamic and heterogeneous nature of m-Learning research.

What Are The Distribution Patterns And Trends Of Keywords Used in m-Learning Research?

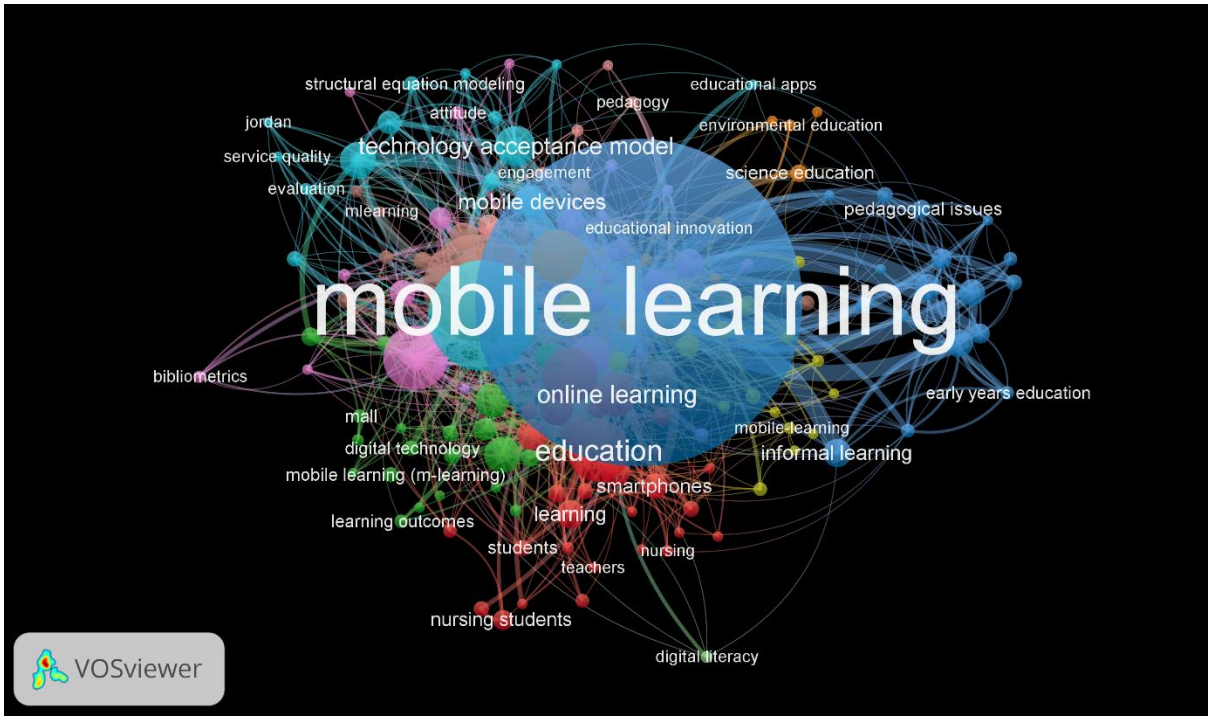

Figure 4: Network Visualisation, Keywords.

The keyword analysis for m-Learning research provides information on the principal themes and issues investigated in the field. "Mobile learning" (m-Learning) is the most commonly used term, with 136 occurrences and the highest total link strength of 254, suggesting its importance in this study topic. The word encompasses the broader research context on mobile-based educational platforms, applications, and approaches. Following closely behind are phrases like "COVID-19", with 51 occurrences and a total link strength of 128, demonstrating the pandemic's major impact on m-Learning research. This high incidence indicates that academics have thoroughly investigated mobile learning's function in aiding distant education during the pandemic, with studies focussing on obstacles, acceptance, and adaptability to suit educational demands during crises.

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Keywords relating to educational practices and technological adoption help to define the focus areas of m-Learning research. The terms "distance education" (32 occurrences, link strength of 80) and "e-learning" (62 occurrences, link strength of 148) highlight the emphasis on remote and digital learning methodologies. The keyword "technology acceptance model" (32 occurrences, link strength of 66) emphasises research efforts to better understand the elements that influence user acceptability of mobile technologies in education, which is crucial for successful deployment. Furthermore, the prevalence of "teaching/learning strategies" (18 occurrences, connection strength of 52) and "technology acceptance" (19 occurrences, link strength of 60) indicates a desire to investigate successful pedagogical strategies and the psychological elements of using m-Learning technologies.

Emerging technologies such as "augmented reality" (47 occurrences, link strength of 122) and "virtual reality" (18 occurrences, link strength of 46) show how innovative techniques are being integrated into m-Learning settings. These technologies enable immersive learning experiences and participatory educational practices, demonstrating the dynamic character of m-Learning research. The prevalence of keywords like "smartphone" (21 occurrences, link strength of 52) and "apps" demonstrates mobile devices' fundamental significance in providing learning flexibility and accessibility. Together, these keywords provide a thorough overview of m-Learning research, indicating areas of interest, technical integration, and pedagogical innovations that continue to define this ever-changing field.

How Do Countries Collaborate in m-Learning Research Through Co-Authorship?

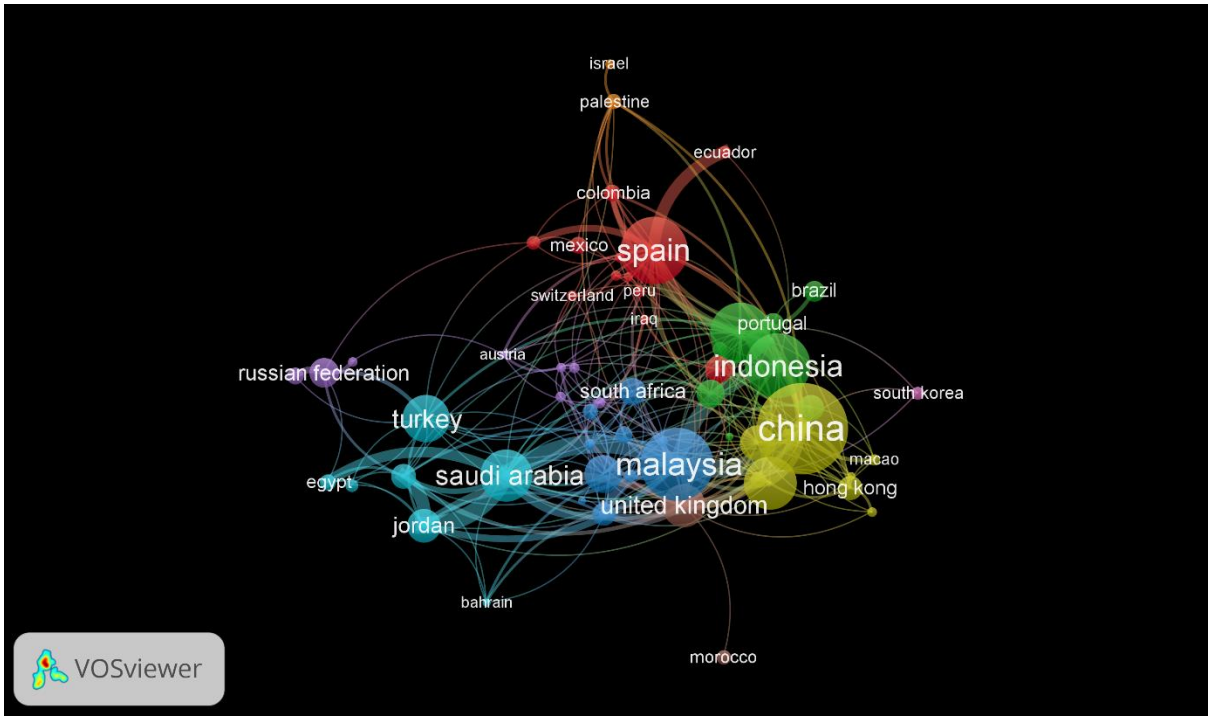

Figure 5: Network Visualisation, Co-Authorship Countries.

The analysis of countries that contribute to m-Learning research reveals a clear concentration of research production in a few major regions. China leads in document output, with 149 publications, 1006 citations, and a total link strength of 70, demonstrating its significant academic concentration on m-Learning and education technology. Malaysia follows closely

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with 109 documents, the most outstanding citation count of 1265, and an 84-point link strength, demonstrating strong international collaboration and influence in the field. This high level of participation in m-Learning research from Asian nations, particularly China and Malaysia, implies that these regions prioritise educational technology improvements, most likely due to the widespread adoption of mobile devices and an increasing emphasis on digital transformation in education.

Other prominent contributors include Saudi Arabia, Spain, and the United States. Saudi Arabia has 67 documents and a significant citation count of 1337, with a link strength of 68, demonstrating its research significance and participation in m-Learning studies. Spain's 97 documents and 1462 citations, with a link strength of 60, demonstrate the country's significant academic contributions to the topic, which European Union digital education programs may have influenced. The United States has 82 publications and 1086 citations, resulting in a link strength of 52, indicating its established research output and collaborations. The active participation of these countries in m-Learning research indicates a wide range of interest in the topic, which is motivated by distinct educational demands and institutional goals.

Countries such as Jordan, Turkey, and India make considerable contributions. Jordan has a high citation-to-document ratio (1009 citations for 36 documents) and a significant link strength of 43, indicating influential m-Learning research. Turkey and India have 58 and 42 documents with reasonably high citation counts, indicating their expanding involvement in educational technology. The persistent participation of European, Asian, and Middle Eastern countries emphasises the global significance of m-Learning research, emphasising joint efforts and shared problems in improving education through mobile technologies in diverse cultural and educational contexts.

Conclusion

Global research trends in m-Learning for education indicate significant patterns across several aspects. The publishing trend from 2020 to 2024 reveals a boom in research output during the pandemic, emphasising mobile learning's relevance in remote education. The following fall indicates a trend towards improving m-Learning apps rather than developing new ones, focusing on consolidating findings and integrating these models with future technologies such as AI. Social sciences and computer science dominate as subject areas, emphasising an interdisciplinary approach that addresses both the human-centred and technological aspects of m-Learning. In contrast, fields such as engineering, medicine, and psychology demonstrate the application of m-Learning across specialised areas, particularly for skill-based and professional education.

Prominent authors who have written outstanding works on various themes have significantly contributed to m-Learning research. Leading scholars have concentrated on gamification and personalised learning, reflecting the educational sector's need for exciting and adaptable teaching techniques. The most referenced papers focus on topics such as emergency remote learning during COVID-19 and using augmented and virtual reality in education, demonstrating a significant interest in responsive and immersive learning experiences. These highly cited studies highlight the integration of m-Learning with cutting-edge technologies such as machine learning and augmented reality, demonstrating a shift towards increasing interactivity, adaptability, and effectiveness in various educational contexts, paving the way for continued evolution in this dynamic field.

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Keyword analysis in m-Learning research identifies major topics and focal points in the discipline. Note that m-Learning emerges as the prominent keyword, highlighting its critical importance in researching educational platforms and techniques that use mobile technology. The prevalence of phrases related to "COVID-19" highlights the pandemic's impact, driving research into mobile learning's adaptation in distant education. Other frequently used keywords include "distance education," "e-learning," and "technology acceptance model," indicating a high interest in digital learning and the variables influencing user adoption of mobile technologies. Furthermore, keywords connected to developing technologies, such as "augmented reality" and "virtual reality," demonstrate the creative ways being integrated into m-Learning to create immersive, interactive environments.

A review of worldwide collaborations in m-Learning research finds considerable contributions from a few important countries. China and Malaysia show out as leaders, with significant document productions and high citation counts, highlighting their active contributions to m-Learning and educational technology. Saudi Arabia, Spain, and the United States make significant contributions, driven by high publication volumes, citation counts, and collaborative connection strengths. These regions' significant research outputs emphasise the importance of m-Learning and digital education efforts. Countries such as Jordan, Turkey, and India have contributed significantly to the worldwide reach and interdisciplinary character of m-Learning research, bringing unique ideas and ways to improve educational practices through mobile technologies. This widespread collaboration underscores a collective effort to tackle educational challenges and innovate within m-Learning across diverse cultural and institutional contexts.

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