PAPER

A Bibliometric Analysis of the Intellectual Landscape of Mobile Technology and Higher Education Research

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ABSTRACT

Technology has become a crucial part of higher education. Higher education institutions have adapted to embrace technology-enabled classroom practices to meet the rising expectations of a varied student population while continually enhancing their learning experience. Mobile technology in higher education, in particular, has the opportunity to provide access to or improve education at a low cost with a less demanding infrastructure configuration. In the current study, the researchers aimed to better understand the intellectual landscape of mobile technology and higher education through bibliometric analysis of research articles published in the Scopus database. This research included a study of 277 papers published in Scopus-indexed peer-reviewed journals between 2006 and 2023. The citation network, co-citation analysis, and publication patterns were examined to discover influential work in this domain. Bibliometric analysis was used to identify the most notable journals, authors, nations, articles, and topics, followed by thoroughly examining the content of 277 papers in the identified clusters. The four major themes enumerated are—Rise of mobile learning, E-learning—the blended and collaborative way, Mobile Technologies in higher education, and Student Engagement in the times of mobile learning. The paper provides interesting insights into these emerging themes, the study will assist regulators, policymakers, and academic scholars in understanding the fundamentals of mobile technology and higher education and identifying pertinent topics for further research.

KEYWORDS
mobile technology, higher education, bibliometric analysis

1 INTRODUCTION

Higher education institutions play a significant role in shaping a country's economic development [1]. They are a vital aspect of the economy since they create a skilled workforce that can take on future employment or become job providers for the economy. Higher education institutions have constantly adapted to external environment changes and progressed over time. Nowadays, the use of technology has become an

essential component of higher education. Higher education institutions have changed their practices to incorporate technology-enabled practices in classrooms to cater to the growing demands of a diverse student group and continuously improve their learning experience [2]. Incorporating technology has enabled them to provide learners and faculty access to flexible online educational services. With online educational services, learners have the flexibility, autonomy, and freedom to study whenever and wherever they desire. Mobile technology in higher education, specifically, offers the ability to give access to or enhance education at a low cost with a less demanding infrastructure setup [3][4]. Mobile learning is an emerging field of research that has attracted numerous scholars. Mobile learning is also popularly called m-learning, flexible learning, or smartphone learning [5]. M-learning offers a wide range of benefits to higher education institutions, such as feasibility, mobility of learners, mobility of faculty, flexibility, etc. Owing to its benefits, there has been tremendous growth in research investigating the impact of mobile learning and mobile technology on students and educators. M-learning researchers strive to maximize the use of mobile technology in higher education institutions while keeping the instructional objective in place.

Smartphones and tablets, internet-connected mobile devices, have become the preferred platform for millennial learners. Today's learners have become more demanding, tech-savvy, and aware of their learning preferences. Hence, higher education institutions must opt for solutions that enable learners to play an active role in their learning process [6]. Institutions must efficiently prioritize using mobile technology resources to facilitate this [7]. According to [8], m-learning allows students to learn contextually, allowing them to respond to experiences they have had in multiple situations. M-learning enables higher education institutions to provide customized learning experiences to each learner, which helps the learner stay dedicated to learning since the learning is tailored to their preferences.

1.1   Research gap and research questions

Mobile technology and its implications for higher education institutions is a fascinating field to investigate, with a substantial body of research to its credit. Existing literature in this domain has focused on aspects of m learning driven by the learner, teacher, and institutions. Infrastructure and technology required for the successful implementation of m-technology in higher education have been a topic of discussion by many researchers. This domain gained momentum post-2013 with the influence of Industry 4.0 in education practices. Learners today are tech savvy, well informed and appreciate technology in the learning process. Research on mobile technology and higher education institutions has seen considerable growth since 2013 and continues to grow further in recent years. This is a testament to the growing importance of mobile technology in higher education spaces. The literature on mobile technology and higher education has significantly changed. There is a strong need to conduct a study that provides a comprehensive view of the nature of work done in this domain. There is also a need to comprehend how the literature on mobile technology and higher education has evolved. This would aid in comprehending the current level of research in this field and provide insight into upcoming areas of interest. The current study uses bibliometric analysis to solve this research gap. Bibliometric analysis is a powerful tool for analyzing a specific study subject with a well-defined structure. It helps offer insights into the type of published work, significant contributors, and research focal points. The researchers have systematically followed the bibliometric analysis approach to address the following research questions:

RQ1: What are the current publication trends in mobile technology and higher education regarding years, sources, and countries?

RQ2: What are this field's most influential papers and research themes?

RQ3: What is the intellectual framework of research on mobile technology and higher education? What are the emerging research trends in this field?

The researchers reviewed publications published in the Scopus database in mobile technology and higher education to find answers to these research areas. The paper's opening part overviews mobile technologies and developing practices in higher education. The next part describes the study's theoretical foundation, followed by the data-collecting approach and research methodology. The findings and discussions are presented at the end of the study.

2 THEORETICAL BACKGROUND

The last few years have witnessed a tremendous rise in mobile phone users [9]. Also, the pandemic of COVID-19 forced higher education institutions to explore alternatives to traditional classrooms [10]. As a result, using smartphones to aid learning gains recognition and acceptance among institutions and learners. M-learning offers many benefits to learners and institutions. It facilitates alternate learning methods while also improving access to education. Mobile technology offers different uses in education. Traditionally, mobile technology was limited to sending mass SMSs to students. Today it has diversified to support effective pedagogies, communications, and e-assessment [11].

Video conferencing is an example of mobile technology in higher education. It is regarded as an effective learning method that allows learners worldwide to engage in the classroom via a wireless smartphone connection. Video conferencing also supports the growing demand for open or distance education where the learners are scattered geographically, and the faculty can connect with the learners via video conferencing. Another application of mobile technology is the gamification of the curriculum. Digital games are trendy among students who grew up in the digital age. Mobile technology supports curricular material by incorporating written material, audio recordings, video animation, and other media types to keep the learner engaged. Mobile technology also helps to assist with e-assessment. E-assessments help faculty assess students online and provide feedback online [12]. Research on mobile technology and higher education has focused on the various mechanisms by which mobile technology makes the teaching-learning process more effective.

3 RESEARCH METHODOLOGY

Bibliometric analysis assists in quantifying the extant literature on a particular research topic. The quantitative nature of bibliometric analysis helps to identify the intellectual structure of the domain of research. Bibliometrics is a popular way to summarise the most significant findings of a collection of bibliographic papers. A bibliometric study, which applies to huge data sets, studies the existing literature to summarise and identify hidden patterns of written communication and the growth of the subject using statistical methods. The technique employs a collection of tools that assist researchers in analysing data, identifying patterns and networks, and researching. The understandings gained through bibliometric analysis assist the

researcher in better understanding the research topic of study by providing critical information on the leading papers, authors, nations, and organizations that have contributed the most and had the most influence on the research field. The bibliometric method has a well-laid-down process to be followed. Data source, screening, and analysis are essential phases in bibliometric analysis.

The research method was divided into two parts. In the first stage, researchers sourced the data relevant to the study from the Scopus database. This data was then filtered for further analysis. In the second stage, the data was analysed using Citation and Co-citation analysis. Citation analysis helped to understand the year-wise publication numbers, countries that have contributed the most in the area of research, dominant authors in the field, their affiliations, funding, most cited articles, etc. The co-citation analysis also helped in identifying the cluster that depicted trends in emerging areas of research in the research field of mobile technology and higher education.

3.1 Data collection

Data sourcing is the first and most crucial step in bibliometric analysis. Data sourcing, also called data collection, is the process of determining the best database for bibliometric analysis, selecting appropriate research terms, and then performing a search command. The researchers used the Scopus database to examine published mobile technology and higher education publications. Elsevier Co.'s Scopus database is well-known and respected. As a worldwide database, Scopus covers more journals than other databases. Scopus gives access to a paper's references, allowing a researcher to navigate ahead and backward in time to locate more literature on the topic of study [13]. Other essential characteristics of the Scopus database, which make it more extensive and easier to use, include an index that assists researchers in identifying open-access titles. Suppose a whole paper is not available in Scopus. In that case, it provides a link to the publisher's web page so that researchers can check the accessibility of the research article on the publisher's website.
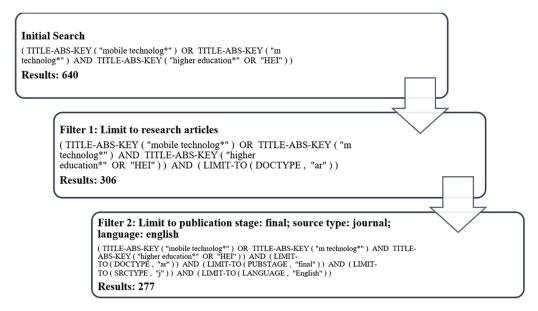
Initial Search
(TITLE-ABS-KEY ("mobile technolog*") OR TITLE-ABS-KEY ("m technolog*") AND TITLE-ABS-KEY ("higher education*" OR "HEI"))
Results: 640

Filter 1: Limit to research articles
(TITLE-ABS-KEY ("mobile technolog*") OR TITLE-ABS-KEY ("m technolog*") AND TITLE-ABS-KEY ("higher education*" OR "HEI")) AND (LIMIT-TO (DOCTYPE , "ar"))
Results: 306

Filter 2: Limit to publication stage: final; source type: journal; language: english
(TITLE-ABS-KEY ("mobile technolog*") OR TITLE-ABS-KEY ("m technolog*") AND TITLE-ABS-KEY ("higher education*" OR "HEI")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English"))
Results: 277

Fig. 1. Data sourcing from the Scopus database

Keyword identification is a crucial component of data sourcing. To ensure accuracy, the researchers conducted a thorough literature review on mobile technology and higher education to identify repeated terms and synonyms. Following the first literature study, the researchers brainstormed to finalize the terminology. Before finalizing the keywords, the usage of relevant BOOLEANs was examined. Figure 1 demonstrates the process of data sourcing.

The initial search string for the study was (TITLE-ABS-KEY ("mobile technology*") OR TITLE-ABS-KEY ("m technology*") AND TITLE-ABS-KEY ("higher education*" OR "HEI")), i.e., the title-abstract-keywords were searched in the Scopus database using keywords "mobile technology*" or "m technology*" and "higher education*" OR "HEI." The search was performed in June 2023. The initial search helped to yield 640 results. The initial search results were a testament to the popularity of research on mobile technology and higher education institutions. The researchers applied two filters to get a more focused result that would yield better interpretations. In the second filter, the search was limited to research articles. Conference papers, Book chapters, Conference reviews, Reviews, Editorials, and Retracted articles were removed from the search. Articles indexed in Scopus are subjected to a rigorous peer review, usually double-blind. Before an article is published, reviewers provide an impartial assessment and comments that are considered. To guarantee excellent study standards, the researchers chose only to utilize papers. This resulted in 306 articles. In the next level, filters were applied to only include papers in the final stage published in journals in English. This resulted in 277 research articles used for the bibliometric analysis.

3.2   Data analysis and inferences

Citation and co-citation analysis are two essential aspects of bibliometric analysis. Citation analysis is based on the weight that academics place on a work when citing it as a source. Citation analysis uses descriptors such as language, authors, institutions, nations, and others to help academics identify critical contributors to the research subject. The publishing frequency split by year makes it easy to see how much research is required on a specific topic. [14] defines co-citation analysis as "the examination of publications that cite a specific pair of references by gathering information from databases and employing analytical and graphic presentation approaches." Co-citation may show content similarities and aid in discovering groupings of themes and researchers and how they may be related. Biblioshiny by R studio and VOS viewer were used in the data analysis.

4   RESULTS

The present research aimed to get in-depth insights from research papers on mobile technology and higher education from 2006 to 2023. Work on consumer socialization first appeared in the Scopus database in 2006. This shows that the application of mobile technology in higher education is a relatively new research topic. The researchers separated the research strategy into three critical phases in the current study. Initially, data was taken from the Scopus database. The prior section went into considerable length about this. The second phase of the research strategy was to examine the search results to present the citation analysis results. Co-citation analysis was performed in the third stage using VOS Viewer and Biblioshiny by R Studio.

The co-citation analysis aided in the identification of new clusters that provide a platform for further research on mobile technology in higher education spaces.

4.1 Descriptive analysis

Overview of research publications. The Scopus database was searched for papers published between 2006 and 2023. There were 277 research papers found throughout the search. The research papers were identified from 179 journals, as shown in Table 1. The average number of citations per document is 21, which is extremely good. From 769 writers, 869 author keywords have been found.

Table 1. Overview of the research

Description	Results
Timespan	2006:2023
Sources (Journals, Books, etc.)	179
Documents	277
Average citations per doc	21.27
References	11599
Keywords Plus (ID)	707
Author's Keywords (DE)	869
Authors	769
Authors of single-authored docs	42
Articles	277

Table 2 shows that until 2012, the number of papers was in the single digits. Since 2013, there has been a significant increase in papers exploring mobile technology in higher education. This may be due to the growing awareness, interest in, and use of mobile technologies. The number of papers submitted on mobile technology in higher education increased significantly in 2019. The pandemic of COVID-19 urged higher education institutions to investigate the appropriate use of mobile technology in teaching evaluation practices. A look at the number of papers after 2019 shows that higher educational institutions have continued practices inculcating mobile technology in teaching-learning and evaluation post-pandemic.

Table 2. Year-wise number of publications

Year	Number of Papers
2023	20
2022	28
2021	29
2020	31
2019	29
2018	24
2017	29

(Continued)

Table 2. Year-wise number of publications *(Continued)*

Year	Number of Papers
2016	15
2015	21
2014	10
2013	15
2012	5
2011	4
2010	3
2009	4
2008	8
2007	1
2006	1

Country wise publications. Table 3 and Figure 2 display the publications by nation. The United States of America has the most research publications on mobile technologies in higher education areas. The United Kingdom, Malaysia, and Australia follow. It is worth noting that both developing and developed countries have recognized the relevance of mobile technology adoption and have contributed to research in this field. The exploration of country-specific citations showed that the United States has the most citations at 1208, followed by South Africa with 383 citations, China with 252 citations, Sweden with 222 citations, and the United Kingdom with 221 citations. This is intriguing since scholars have prioritized studies done in developing countries to better understand this research domain.

Table 3. Country wise publications

Country	Number of Papers	Number of Citations
United States	52	1208
United Kingdom	26	221
Malaysia	24	185
Australia	23	197
Spain	16	173
China	15	252
Saudi Arabia	9	180
United Arab Emirates	9	95
Canada	8	55
Hong Kong	8	115
South Africa	8	383
Turkey	8	42
South Korea	7	165
Sweden	7	222

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Fig. 2. Country wise publications

Most cited article. Table 4 shows the top ten most cited articles. "Mobile learning: A framework and evaluation," published in 2007, was the most cited paper with 637 citations and total citations per year as 37. This article [15] explored the extension of Short Message Services (SMS) and Wireless Access Protocols (WAP) in e-learning effectiveness. The framework for mobile learning was used as a basis to study the same. The study provided a comprehensive framework for developing mobile learning applications for distance and e-learning. "Defining mobile learning in the higher education landscape," published in 2010, was the most cited paper with 341 citations and a total of citations per year 24. In this paper, the authors aimed to break down the concept of mobile learning. The article discussed the meaning of mobile learning by relating its primary components to learning experiences in higher education. The article "Analysis of the essential factors for adopting mobile learning in higher education: A case study of students of the University of Technology" had 209 citations and a high total citations per year of 34. This article examined the usage of mobile learning (m-learning) in higher education [16].

Table 4. Top ten most cited articles

Sr No	Title	Number of Citations	DOI	TC Per Year
1	Mobile learning: A framework and evaluation	637	10.1016/j.compedu.2005.10.011	37.47
2	Defining mobile learning in the higher education landscape	341		24.36
3	Analysis of the essential factors for the adoption of mobile learning in higher education: A case study of students of the University of Technology	209	10.1016/j.tele.2017.09.016	34.83

(Continued)

Table 4. Top ten most cited articles *(Continued)*

Sr No	Title	Number of Citations	DOI	TC Per Year
4	Cross-cultural analysis of users' attitudes toward the use of mobile devices in second and foreign language learning in higher education: A case from Sweden and China	149	10.1016/j.compedu.2013.07.014	13.55
5	The use of a mobile learning management system and academic achievement of online students	129	10.1016/j.compedu.2016.07.003	16.13
6	Applying the UTAUT Model to Explain the Students' Acceptance of Mobile Learning System in Higher Education	122	10.1109/ACCESS.2019.2957206	24.40
7	The use of a mobile learning management system at an online university and its effect on learning satisfaction and achievement	120	10.19173/irrodl.v16i3.1984	13.33
8	Parental involvement and attitudes towards young Greek children's mobile usage	99	10.1016/j.ijcci.2019.100144	19.80
9	Understanding higher education learners' acceptance and use of mobile devices for language learning: A Rasch-based path modelling approach	95	10.1016/j.compedu.2019.103761	23.75
10	Students' attitudes towards the use of mobile technologies in e-Evaluation	78	10.3991/ijim.v11i5.6879	11.14

Bradford distribution and source dynamics. Source dynamics illustrate the yearly appearances of the word mobile learning and higher education across multiple sources, i.e., journals. 159 journals published papers on related topics. Table 5 shows the top ten most influential journals based on the number of papers published in Mobile technology and Higher education. International Journal of Interactive Mobile Technologies had the maximum number of papers in the given area. Education and Information Technologies followed this. The top 20 Journals ranged from a cite score of 22 of 2.9 to 23.8. The oldest Journal to be part of the Scopus database was the British Journal of Educational Technology in 1970, and the most recent to become part of the Scopus database was Call Ej in 2013. (As per Scopus database definition: Calculating the Cite Score is based on the number of citations to documents (articles, reviews, conference papers, book chapters, and data papers) by a journal over four years, divided by the number of the same document types indexed in Scopus and published in those same four years. For example, the 2022 Cite Score counts the citations received in 2019–2022 to articles, reviews, conference papers, book chapters, and data papers published in 2019–2022 and divides this by the number of these documents published in 2019–2022.) Table 6 shows that the Computer and Education journal pioneered in publishing a research paper recognizing the need for mobile technology in higher education spaces. The International Journal of Interactive Mobile Technologies has the maximum number of papers published in this domain from 2019–2023.

Table 5. Most influential source based on number of research papers

Sr No.	Journal Name	Number of Papers	Cite Score 2022	Publisher	Scopus Coverage from to Present	Quartile	H Index	Total Cites 2022
1	International Journal of Interactive Mobile Technologies	14	4.2	International Association of Online Engineering	2007	Q3	29	1851
2	Education and Information Technologies	12	8.2	Springer Nature	1996 to 2002; 2005	Q1	61	6213
3	Computers and Education	8	23.8	Elsevier	1976	Q1	215	9988
4	International Journal of Mobile and Blended Learning	6	3.4	IGI Global Publishing	2009	Q2	20	112
5	International Journal of Mobile Learning and Organisation	6	6.1	Inderscience Publishers	2007	Q2	27	216
6	International Review of Research in Open and Distance Learning	6	5.6	Athabasca University	2000	Q1	83	179
7	Telematics and Informatics	5	16	Elsevier	1984	Q1	93	4179
8	Interactive Technology and Smart Education	4	8.5	Emerald Publishing	2004	Q1	27	610
9	International Journal of Emerging Technologies in Learning	4	5	International Association of Online Engineering	2008	Q2	39	3956
10	Research in Learning Technology	4	5.2	Association for Learning Technology	2012	Q2	34	291

Table 6. Year-wise papers published

Year	International Journal of Interactive Mobile Technologies	Education and Information Technologies	Computers and Education	International Journal of Mobile and Blended Learning	International Journal of Mobile Learning and Organisation	International Review of Research in Open and Distance Learning
2006	0	0	0	0	0	0
2007	0	0	1	0	0	0
2008	0	0	1	0	2	0
2009	0	0	1	0	3	0
2010	0	0	1	0	4	0
2011	0	0	1	1	4	0
2012	0	0	1	1	4	0
2013	0	0	3	3	4	0

(Continued)

Table 6. Year-wise papers published *(Continued)*

Year	International Journal of Interactive Mobile Technologies	Education and Information Technologies	Computers and Education	International Journal of Mobile and Blended Learning	International Journal of Mobile Learning and Organisation	International Review of Research in Open and Distance Learning
2014	0	0	3	4	4	1
2015	2	0	3	4	4	3
2016	4	1	4	4	4	4
2017	6	1	5	4	4	5
2018	6	2	5	5	4	5
2019	6	3	5	6	4	6
2020	12	5	7	6	5	6
2021	13	5	7	6	5	6
2022	14	8	8	6	5	6
2023	14	12	8	6	6	6

The research used Bradford's law to characterize the order of distribution of journal titles on a specific topic. [17] stated that the law operates on centric productivity zones, illustrating that there are diminishing returns when the literature is comprehensive and over-explored. According to Bradford's Law, journals can be separated into several zones based on the number of articles. As shown in Figure 3, as per Bradford's dispersion law, there are three zones. Zone 1 has 17 journals, zone 2 has 71 journals, and zone 3 has 91. Bradford's law of scattering predicts an increase in journal production from one zone to the next. The 17 journals in zone 1 are the core journals in mobile technology and higher education. These journals include the International Journal of Interactive Mobile Technologies, Education and Information Technologies, Computers and Education, the International Journal of Mobile and Blended Learning, etc.
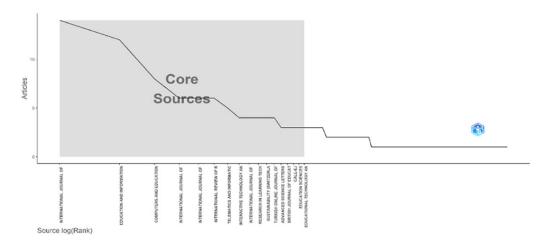

Fig. 3. Core Sources based on Bradford's law

Keyword analysis. The results of Biblioshiny shown in Figure 4 show that higher education occurred the most frequently, with 96 occurrences, followed by mobile learning with 75 occurrences and mobile technology with 68 occurrences. Mobile learning has been closely linked to e-learning (24 occurrences). Other important author keywords include smartphone, technological acceptance model, collaborative learning, student engagement, gamification, education technology, and information literacy.
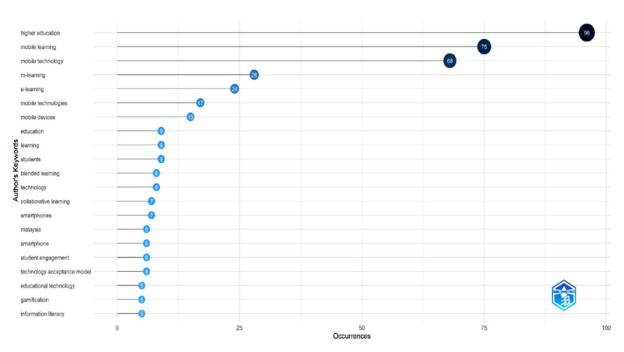
Fig. 4. Frequently occurring Author keywords

A further analysis of trending topics over the years (demonstrated in Figure 5) shows that in the initial years of research from 2011–2016, student engagement and pedagogies to keep students engaged were the prime focus of research. The Technology Acceptance Model (TAM) provided exciting insights into learners' acceptance of technology. This gave rise to discussions around educational technology. Research on Mobile Learning and E-learning gained significant importance during 2017–2020. The term mobile technology had the highest frequency (75) in 2019. The pandemic is one of the significant contributors to this, where higher education institutions had to shift from physical classes to virtual classes. Institutions sought feasible, accessible, and available alternatives for learners in the virtual learning environment. The popularity of m-learning through smartphones grew during this period. Recent literature has focused on online learning, mobile-assisted learning, smartphones, and e-learning.
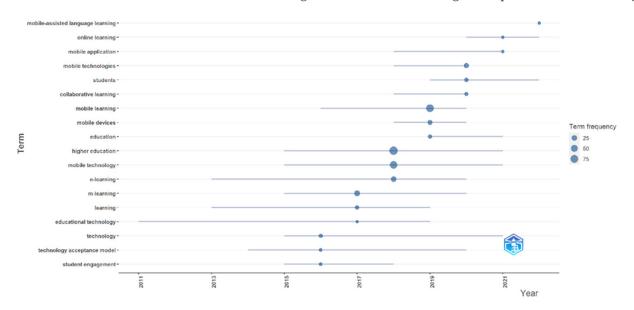

Fig. 5. Trending topics from 2011–2023

Three-field plot. The three-field plot shown in Figure 6 shows the relation between any three fields under study using Sankey plots. Three-field plots, known as Sankey diagrams, show the relationships between multiple elements in a research database. Sankey diagrams visualize the different systems and their discussions [18]. The researchers compared three fields, i.e., country, source, and author key-words. The number of items was restricted to 10 for each search tab. The size of the node indicates the value of the work done. Australia, the United States, the United Kingdom, and Malaysia have contributed extensively to the key journals International Journal of interactive mobile technologies, education, and information technologies. The Sankey plot shows that researchers from different countries have published in Scopus journals of quartiles Q1 to Q3 that are linked to information technology, m-technology, learning technology, and interactive technology in higher education. The main focus of researchers has been to understand mobile learning initiatives taken up by higher education institutions, the use of mobile technology to aid e-learning, smartphones, and m-learning popularity among students. The plot shows that maximum work on mobile learning and higher education has been done.
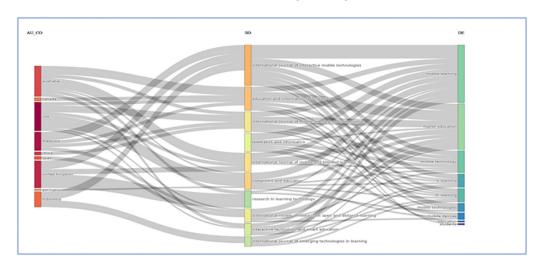

Fig. 6. Three field plot-Country-source-keywords

4.2 Co-citation analysis

Co-occurrence of author keywords. *Co-occurrence* is a network that aids in ana-lysing potential relationships between various elements. Keywords are an essential component of every research document. Writers provide author keywords and indi-cate the primary emphasis of the study field. The co-occurrence of author keywords aids in determining the most common subjects covered in the given field of study. They also aid in spotting upcoming research trends. The map shown in Figures 7 and 8 was created using VoS viewer software by the authors. The nodes indicate keywords; their size is proportional to how often the term appears in the papers. The connections represent the relationships between two nodes, and the link's width indicates the association's strength. Thus, the larger the node's size, the more times the keyword has appeared. The network thus constructed is a representation of the cumulative knowledge of a domain.

Further, for analysis, we clubbed the exact sounding and exact meaning words together and set the minimum occurrence of keywords to 5. Out of 862 keywords, 21 keywords met this threshold value. Overall, we had 21 keywords divided into

5 clusters with 21 items, 88 links, and 315 link strengths. The top three keywords according to link strength were: Mobile learning (link strength 137; occurrence 105), Higher education (Link strength 132; occurrence 102), Mobile technologies (link strength 107; Occurrence 85).
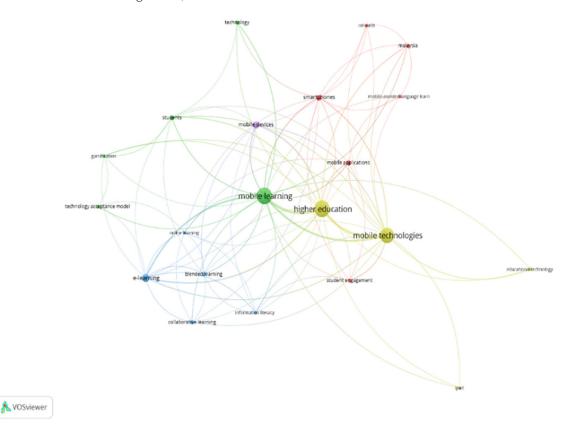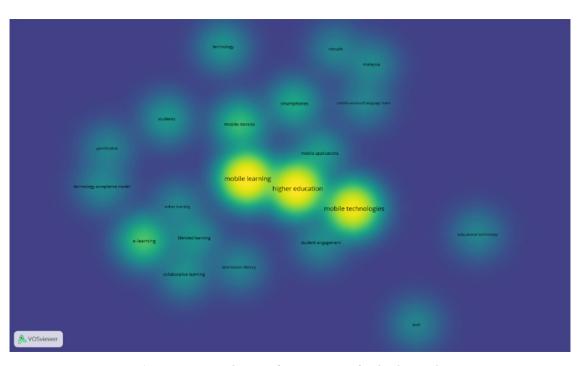

Fig. 7. Co-occurrence of author keywords

Fig. 8. Density visualization of co-occurrence of author keywords

Cluster 1: Rise of mobile learning. Technology has changed the world in the last two decades. The education sector, too, has seen its fair share of changes due to technology. The developments in information and communication technology and the pandemic accelerated the use of mobile devices in learning. In a medical University in Moscow, the share of students using smartphones for learning increased from 10.4% in 2015–16 to 61.5% in 2019–20 [19]. Cluster 1 looks at the rise and impact of mobile learning. Students found mobile learning helpful and accessible during the pandemic. Students found easy access to resources and valuable course material due to using mobile technology in learning [20] [21]. The mobile learning experience is dependent on many factors. The perceived usefulness and ease of use depended on the mobile system's and service's efficacy. Learning autonomy and well-designed mobile learning tools added new dimensions to learning [22] [23]. As a tool to increase student learning and engagement, gamification has also gained significance [24] [25]. Different papers in Cluster 1 have also proposed different models to improve student engagement and learning for mobile learning [26]. Technology and multiple learning environments are part of the future of the education sector, and mobile learning is here to stay.

Cluster 2: E-learning-the blended and collaborative way. Digital technologies are indispensable to the learning process and are here to stay. Nevertheless, there needs to be more clarity in defining the terms that seemingly look the same and are used interchangeably. [27] have tried to differentiate between various terms like e-learning, online learning, virtual learning, web-based learning, etc. While the majority of the papers of Cluster 2 do agree that learning through technological devices is here to stay, the papers also bring forth challenges. Regular online support of teachers and fellow students had a significant role in successful collaborative mobile learning [28]. Integrating mobile technology helped the students to be flexible in their location and schedule of learning. It also allowed interaction between the students during lessons and outside them [29] [30]. Strengthening teachers' digital competence is crucial for the effective teaching-learning process [31]. E-learning is playing a dynamic role as online classrooms are challenging traditional classrooms. The fusion of collaborative and blended learning and multichannel teaching approach can effectively enhance the teaching-learning experience. Collaborative learning was positively influenced by mobile technology for engineering students and theatre art students [27] [32]. Researchers have proposed various models to integrate different online pedagogy for effective online classrooms [28] [33]. Though e-learning has witnessed a considerable leap during and post-pandemic, quality has been an area of concern. Development and enhancement of content, videos, interactive tools, and collaborative and blended learning are some proposed tools to support positive outcomes for all stakeholders [34].

Cluster 3: Mobile technologies in higher education. Cluster 3 explores various technologies used for mobile-based interventions in higher education. The common consensus among the papers was that mobile learning has the potential to change the landscape of higher education on many fronts, like culture, pedagogy, technology development, and accessibility [35]. Multimedia design, diversified content, learning videos, trust, perceived usefulness, behavioural intention, flexibility, and accessibility were some of the factors identified that impact mobile learning [36] [37] [38]. Optimal use of mobile technology depended on teachers' excellent proficiency in technology and selecting suitable software. Performance expectancy, facilitating conditions, hedonic motivation, and habit also affected faculty use of mobile technology [37] [39]. Easy accessibility to social media was a concern for students' academic performance [40]. Different authors proposed models using different mobile

technologies for a better and more valuable mobile learning environment [15] [41]. Overall, the cluster indicates that mobile technologies are essential to higher education.

Cluster 4: Student engagement in the times of mobile learning. Cluster 4 explores the challenges of student engagement using mobile devices. Student engagement had a direct relationship with the involvement of the teachers in supporting and using mobile technologies. High self-efficacy of the instructor in using mobile technologies and understanding the factors associated with student engagement were essential parameters for positive student engagement [42] [43]. Mobile learning engagement was further classified as social, cognitive, emotional, and behavioural [41]. Integrating mobile devices with clicker systems or the BYOD (bring your device) approach also positively impacted student engagement [43] [44]. The cluster also had papers discussing and deliberating on mobile applications. Principles of problem-based learning were recommended for the design and implementation of mobile applications [27]. Overall, students showed a positive attitude toward the educational use of smartphones [45] [46].

4.3 Thematic map

Thematic keyword mapping identifies study themes, crucial words, and the links between them [18]. A network analysis based on the occurrences of words was used to summarize what research says in an area and significant themes and trends. As shown in Figure 9, thematic mapping classifies literature in a particular domain of study into four themes [17]: Motor themes, basic themes, emerging or declining themes, and niche themes.
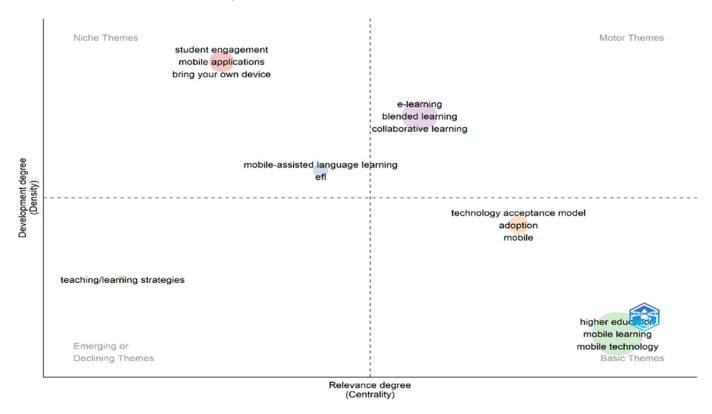

Fig. 9. Thematic map of mobile technology and higher education

Themes in the quadrant on the upper right have considerable centrality and concentration and are essential to the field; these are called motor themes. These themes are central to the field and the most often discussed topics; they have highly significant relevance to the domain of research: "e-learning," "blended learning," and "collaborative" are the themes that have occurred in this space. Integrating mobile technology for effective teaching-learning pedagogies has been an area of focus of higher education institutions; numerous researchers have started discussions on how to use smartphones and m technology for enhanced learning experiences effectively. The pandemic opened multiple opportunities for higher education institutions to explore the virtual learning space. Blended learning is an area of research that has emerged due to this.

Further mobile technology also aids collaborative learning with learners spread across the country and globe. "Technology acceptance model" appears in the basic theme that indicates that the research domain is essential but needs more and more significant research attention. The model highlights how end users, in this case, learners, can accept and successfully use a new technology, mobile technology. The themes in the upper left quadrant are characterized by low density and high centrality; hence, these themes are often referred to as niche themes in this study. They have been identified as "Student engagement" and "Bringing one's device." These themes are well-developed with internal linkages but have poor exterior relations. The lower left quadrant theme represents emerging and declining ties "teaching learning strategies" emerge in this theme.

5   CONCLUSION AND SUMMARY OF RESEARCH FINDINGS

Technology has had a significant impact on the education sector. There is a growing need for higher education institutions to invest in technology and adopt pedagogies that embrace the technology. Mobile technology has changed how faculty deliver their classes and assess learners. Optimal use of mobile technology depended on teachers' excellent proficiency in technology and selecting suitable software. Since 2013, there has been a significant rise in studies on mobile technology and higher education. This illustrates the rising relevance of mobile technologies in higher education. However, there was an urgent need for research that offered a thorough picture of the specific type of work done in this area of study, to identify past, present and emerging trends in this domain. To address this research gap, the current study applied bibliometric analysis. The purpose of this study was to comprehend the past and present state of research in this sector and offer insight into future areas of interest. The study included information pertaining to the different kinds of published work, significant contributors, and research interests. The study aimed to primarily address three research questions.

The first research question aimed to identify the current publication trends in mobile technology and higher education with emphasis on the year wise publication trend, sources, and leading countries that have contributed in this domain. The analysis shows that until 2012, the number of papers was in single digits. Since 2013, there has been a significant increase in papers exploring mobile technology in higher education. This may be due to the growing awareness, interest in, and use of mobile technologies. The number of papers submitted on mobile technology in higher education increased significantly in 2019. International Journal of Interactive Mobile Technologies had the maximum number of papers in the given area. Education and Information Technologies followed this. A look at the country-wise contributions shows that the United States of America dominates the list, followed by the United

Kingdom. It was also interesting to note that both developed and developing countries have contributed to this research area. Citation analysis was used to address the second research question that aimed to understand this field's most influential papers and research themes. The citation analysis results show that the most cited article was "Mobile Learning: A Framework and Evaluation," published in 2007 with 637 citations. A look at the thematic map showed that "e-learning," "blended learning," and "collaborative" were the motor themes, "Technology acceptance model" appeared in the basic theme, and "Student engagement" and "Bringing one's device" were the niche themes. The lower left quadrant theme represented emerging and declining ties; "teaching learning strategies" emerged in this theme. The final research question aimed at identifying the emerging trends in mobile technology and higher education. Drawing on the results of cluster analysis, the keywords help in defining four broad research themes. Cluster 1: Rise of mobile learning, Cluster 2: E-learning-the blended and collaborative way, Cluster 3: Mobile technologies in higher education, and Cluster 4: Student engagement in mobile learning. Understanding this area of study is critical and has various implications. From a theoretical standpoint, mobile technology in higher education aids in a better understanding of how higher education institutions might embrace m learning. The four distinct clusters highlight rising research areas that point the way forward for future scholars.

6   CONTRIBUTIONS AND IMPLICATIONS OF THE STUDY

The study shows that research on mobile technology in higher education has opened up opportunities for higher education institutions to provide education that has enhanced applicability, accessibility, engagement and encourages collaboration among faculty and learners. From a theoretical standpoint, comprehending the use of mobile technology in higher education aids in a better understanding of the acceptability and practises of incorporating mobile learning processes and their outcomes, which is a vital aspect of higher education literature. The research would be useful for academicians, academic leadership and policy makers to device policies and strategies that would encourage the implementation of m learning through smartphones, tablets that learners can access as per their convenience. The policies could also focus on infrastructure for m learning such as digital libraries, e books and adoption of technology-enabled pedagogies such as gamification, collaborative learning, augmented reality that would keep learners curious, motivated and engaged. This necessitates the establishment of numerous effective and efficient policies, as well as instructions from academic leadership, to encourage the use of mobile technology in higher education.

7   LIMITATIONS AND SCOPE FOR FURTHER RESEARCH

The current study is one of the few attempts to give a thorough knowledge of the literature on mobile technology and higher education. The investigation was carefully and methodically carried out by the researchers. However, several limitations must be addressed. The researchers exclusively used research papers from the Scopus database. Although Scopus is a well-known and trustworthy database, it may exclude specific important papers indexed in other databases, such as the Web of Science. This research might be expanded by conducting a bibliometric analysis of Web of Science-indexed journals' search results. It would be fascinating to compare the bibliometric outcomes of the Scopus and Web of Science databases.

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