Online-Journals.org

iJIM International Journal of Interactive Mobile Technologies

iJIM | eISSN: 1865-7923 | Vol. 17 No. 20 (2023) | OPEN ACCESS

https://doi.org/10.3991/ijim.v17i20.45037

PAPER

Data-Driven Insights in Higher Education: Exploring the Synergy of Big Data Analytics and Mobile Applications

Ishamuddin Mustapha[1], Vichayanan Rattanawiboonsom[2](✉), Ruankwan Intanon[2]

[1]Malaysian Institute of Industrial Technology (MITEC), Universiti Kuala Lumpur, Kuala Lumpur, Malaysia

[2]Faculty of Business, Economics, and Communications, Naresuan University, Phitsanuloke, Thailand

vichayananr@nu.ac.th

ABSTRACT

This study explores the potential for transformation that may be achieved via the use of big data analytics and mobile apps in the context of higher education, specifically emphasizing the role of data-driven decision-making. Within the contemporary educational landscape, characterized by the increasing impact of digital technology and mobile devices, institutions of higher education are actively investigating innovative strategies. That enhances effectiveness, customizes learning experiences to suit individual students, and develops overall student accomplishments. The main objective of this research is to examine the effects of incorporating big data analytics and mobile applications into the decision-making capacities of higher education establishments. The PRISMA Statement was used to guide the selection and exclusion of records using the RStudio Biblioshiny approach for data analysis. A comprehensive review of the existing scholarly works, identification of groupings, and study of citation trends within the field. The results and findings illustrate the inherent importance of "big data," "cloud computing," "mobile computing," and "higher education" in the field of research, underscoring their crucial role in data-driven decision-making. Furthermore, the study underscores the significant impact of contemporary technology on administrative processes, personalized learning, and scholastic attainment. This research provides a great addition to the academic field by presenting insightful findings on the substantial influence of big data analytics and mobile applications on the evolution of higher education. This study emphasizes the need to adopt data-driven insights to successfully navigate the ever-changing landscape of higher education.

KEYWORDS

higher education, big data analytics, mobile applications, data-driven decision-making

1 INTRODUCTION

The use of big data analytics in higher education is having a transformative impact, as it provides institutions with unparalleled insights and capabilities [1]. The transforming influence of this phenomenon has been widely reported in

Mustapha, I., Rattanawiboonsom, V., Intanon, R. (2023). Data-Driven Insights in Higher Education: Exploring the Synergy of Big Data Analytics and Mobile Applications. *International Journal of Interactive Mobile Technologies (iJIM)*, 17(20), pp. 21–37. https://doi.org/10.3991/ijim.v17i20.45037

Article submitted 2023-08-16. Revision uploaded 2023-09-20. Final acceptance 2023-09-20.

scientific research publications [2]. The use of big data analytics enables higher education institutions to effectively utilize large amounts of data, ranging from student records to online learning interactions, to identify significant patterns and trends [3]. According to [4], using predictive analytics, educational institutions can anticipate the requirements of students and react proactively in order to improve student retention rates and overall academic achievement.

In addition, the implementation of data-driven suggestions is facilitating the development of personalized learning paths, therefore customizing educational experiences to meet the unique needs of individual students [5]. Furthermore, the streamlining of administrative procedures, optimization of resource allocation, and realization of financial savings are achieved via the use of data-informed decision-making [6]. On the other hand, scientific studies have provided evidence that the use of big data analytics not only enhances administrative operations but also enhances the overall quality of the teaching and learning experience [7]. Instructors may obtain real-time data on student performance, allowing for rapid course modifications and focused interventions [8]. In the realm of higher education, the use of big data analytics is fundamentally reshaping the landscape as it enables the adoption of evidence-based decision-making, personalized learning experiences, and data-driven initiatives aimed at fostering ongoing enhancements [9].

The convergence of big data analytics and mobile applications is precipitating a substantial paradigm shift within the realm of higher education, particularly with regard to the implementation of data-centric decision-making methodologies [10]. These technologies enable the acquisition, manipulation, and immediate examination of vast amounts of data inside higher education institutions, thereby facilitating flexible and knowledgeable decision-making [11]. Additionally, mobile applications provide extensive accessibility to educational resources and platforms, leading to a significant accumulation of data on student interactions and engagement [12]. When combined with big data analytics, the use of this information has the potential to provide valuable insights into student behaviors and preferences [13]. Consequently, this may enable adjustments to the curriculum and the implementation of customized learning interventions [14].

Furthermore, these technologies provide administrators and educators with the capability to efficiently manage resources, enhance course design, and tailor support services in order to attain enhanced student outcomes [15]. In addition, predictive analytics tools facilitate the use of data-driven techniques, allowing educational institutions to accurately identify students who are at a heightened risk of attrition. Consequently, these institutions can swiftly implement targeted interventions, resulting in improved rates of student retention [16]. The integration of big data analytics and mobile applications in higher education fosters an atmosphere in which data-driven decision-making transitions from a potential opportunity to a tangible reality [17]. The utilization of these technologies holds the promise of generating a substantial paradigm shift within the realm of education. This shift would be characterized by the establishment of a symbiotic relationship, thereby fostering the advancement of students, optimizing the operational effectiveness of educational institutions, and facilitating continuous growth and evolution [18]. Finally, the main aim of this study is to examine and illustrate the impact of using big data analytics on the decision-making capabilities of higher education institutions, with a specific focus on mobile-driven processes and technology. Additionally, the objective of this research is to explore the possible impact of big data analytics on improving the operational efficiency, effectiveness, and decision-making capacities of higher education institutions.

2 MATERIALS AND METHODS

The preferred reporting items for systematic reviews and meta-analyses (PRISMA) framework was used to collect data in a systematic way that would make it easy to conduct an extensive literature review [19] [20]. As the de facto industry standard for the systematic presentation of empirical data in the context of systematic reviews and meta-analyses in academic research, PRISMA is the industry standard [21]. The Scopus database was chosen as a suitable and reliable source for this investigation to guarantee the identification of relevant information. On September 1st, 2023, the Scopus database was the target of a targeted search technique. The goal of this technique was to find relevant academic publications using the keywords "mobile applications," AND "big data analytics," AND "higher education institutions."

There were 97 results in total from the original search. The inclusion of peer-reviewed scientific contributions was then ensured by using a discriminating approach to eliminate reports, conference proceedings, and theses. There were assigned topic areas for computer science, engineering, mathematics, business, management, environmental sciences, finance, economics, and econometrics to further narrow the search and increase its relevance. These selection criteria were specifically designed to provide more reliable and applicable results within the selected study topic.

Additionally, the selection of articles followed five strict criteria that included:

2.1 Refereed academic publications

The research only included articles from refereed academic publications, ensuring the highest levels of academic rigor and peer review.

2.2 Temporal consideration

To guarantee the inclusion of current and relevant academic dialogue, a temporal component was included, limiting the selection to publications published during the last twelve years (from 2010 to 2023).

2.3 Scopus indexing

Publications that were indexed by Scopus were taken into consideration to sustain a standard for academic acknowledgement and dissemination.

2.4 Relevance to study focus

Selected papers had to provide a significant contribution to the discussion of big data analytics and mobile applications in the context of higher education, closely fitting with the goals of the study.

The PRISMA flow diagram, shown in Figure 1, provides a visual depiction of the systematic review process. This flowchart shows how studies advance through each stage of the review process, culminating in the inclusion of 42 papers that satisfied the exacting standards set for this research project.

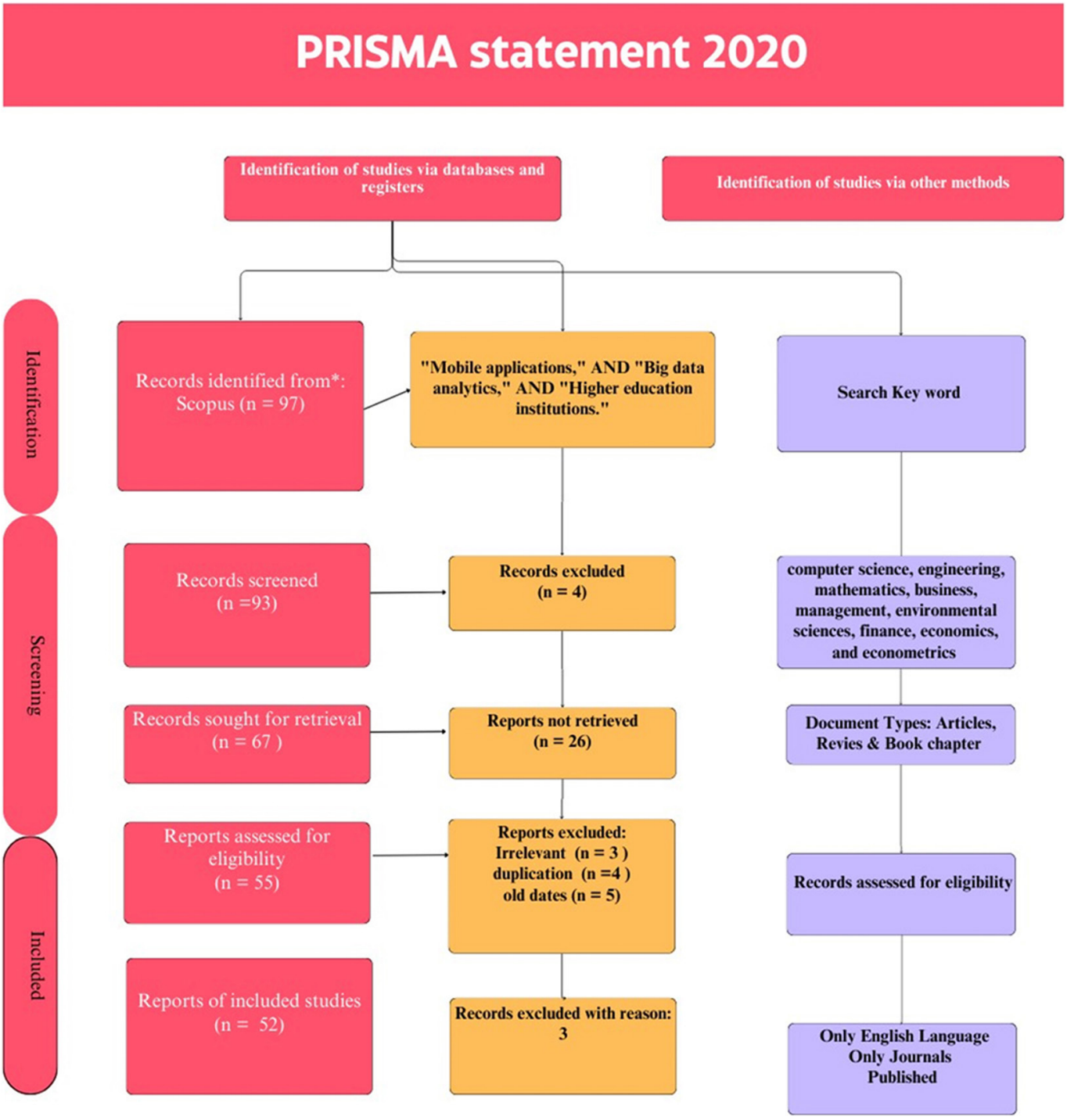

Fig. 1. PRISMA statement inclusion and exclusion criteria

3 DESCRIPTIVE

Table 1 presents a detailed summary of the data gathered and offers key statistical insights into the major features of the dataset utilized in the study. The records were included in the 2010–2023 timeframe for data gathering and analysis, covering a wide temporal range that enables the examination of trends and advancements

in the study's topic of interest throughout a sizable time. In addition, there are 34 sources in the dataset, the majority of which are books, journals, and other scientific publications. This broad range of resources guarantees a complete and in-depth examination of the subject at hand. Moreover, Table 1 lists 42 documents as the total number of real documents in the collection. This amount represents the depth of research that was considered in the study and offers a sizable body of data for analysis and synthesis.

The dataset has an annual growth rate of 11.25%, indicating a substantial increase in the quantity of relevant documents throughout the specified period. The observed growth rate may serve as an indicator of the increasing level of interest and scholarly involvement in the subject matter as time progresses. The dataset demonstrates contemporaneity, evident in the average document age of 3.38 years. This observation suggests that the bulk of documents in the collection are of recent origin, which aligns with the study's focus on contemporary trends. The dataset's papers' academic significance and importance are shown by the average number of citations per document, which stands at 13.83. The papers in this area exhibit high relevance, as indicated by a notably higher average citation count, implying that these documents are frequently referenced by other academic publications. Additionally, the dataset boasts a substantial total of 1772 references. This suggests that the dataset's documents build on a variety of previous works, demonstrating a rigorous scholarly approach and thorough examination of the topic. Finally, the table illustrates the information on the keywords used before we get to the paper's contents. A look at the dataset's 282 Keywords Plus (ID) and 183 Author's Keywords (DE) entries reveals the variety and depth of terms and ideas used to describe the study subject.

Besides this, there are 141 writers who have been recognized as having contributed to the dataset. Unusually, only one document has a single author, while the others have many authors, demonstrating the collaborative nature of the field's study. The table's average of 3.48 co-authors per document in the context of author cooperation emphasizes the collaborative character of academic research in this field. Furthermore, foreign co-authorships are present in 16.67% of the partnerships, demonstrating the scientific community's global outlook and reach. The collection largely comprises articles (38) and reviews (4) as document types. According to this distribution, academic publications seem to be the most common kind of contribution to the area, with a lesser number of review articles that critically summarize and critique current research coming in second.

Table 1. Main information

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2010:2023
Sources (Journals, Books, etc.)	34
Documents	42
Annual Growth Rate %	11.25
Document Average Age	3.38
Average citations per doc	13.83
References	1772

(Continued)

Table 1. Main information *(Continued)*

Description	Results
DOCUMENT CONTENTS	
Keywords Plus (ID)	282
Author's Keywords (DE)	183
AUTHORS	
Authors	141
Authors of single-authored docs	1
AUTHORS COLLABORATION	
Single-authored docs	1
Co-authors per doc	3.48
International co-authorships %	16.67
DOCUMENT TYPES	
article	38
review	4

In addition, Figure 2 presents a graphical depiction of the distribution of articles within the dataset throughout several years, including the period from 2010 to 2023. The presented chronology of article publishing provides valuable insights into the progression and patterns of research endeavors within the selected field. During the early years, particularly in the years 2010, 2011, and 2012, there was a dearth of activity, as seen by the publication of just one paper in 2010 and 2013. This implies that the topic of investigation may not have received much recognition within the scholarly community during its first stages or that research and scholarly publications were still in their early stages of development.

However, there is a discernible shift in the data starting with the year 2015. In the year 2015, there was a notable rebound in the publication of academic publications, which was afterwards followed by a steady and consistent rise in the yearly number of articles being published. Significantly, in the year 2016, there was an increase in the number of papers to three, which suggests a growing interest in the study subject. The years 2018 and 2019 demonstrate a notable increase in research productivity, as shown by the publication of three publications in 2018 and seven articles in 2019. The observed increase in interest might suggest an emerging acknowledgement of the significance and applicability of the topic, perhaps influenced by developments in technology, shifts in educational methodologies, or other contributing factors. A prominent pattern is seen for the years 2020, 2021, and 2022, whereby the annual publication count exhibits a considerably elevated level, with 7, 11, and 4 articles, respectively. This observation indicates a notable rise in academic interest in the subject, maybe motivated by the widespread use of mobile apps worldwide and the increasing importance of big data analytics in many industries, including the field of higher education. The dataset terminates in 2023, with a total of four articles. This suggests that ongoing research on the respective topic continues to be dynamic and relevant in the current year.

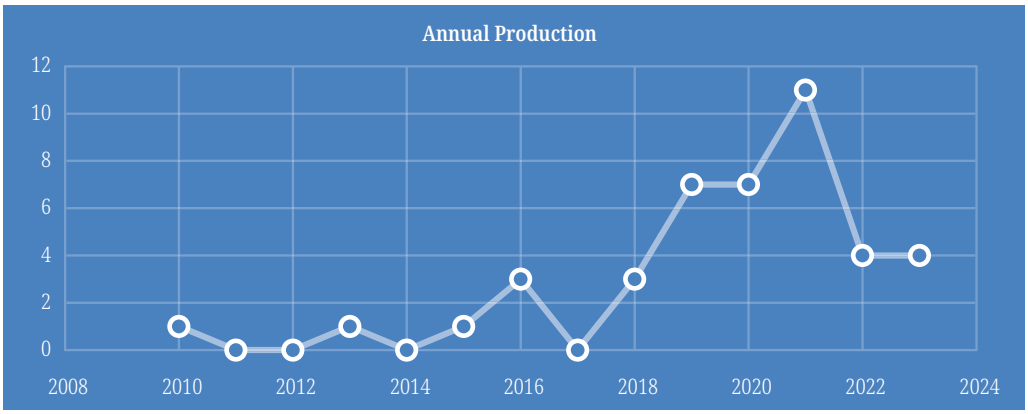

Fig. 2. Annual production of articles from 2020–2023

Figure 3 offers vital information about the primary sources or journals that have made substantial contributions to the existing body of literature on the selected study subject. Figure 3 offers a comprehensive compilation of sources, along with the corresponding count of articles from each source that have been included in the dataset. This information serves to illuminate the sources that have shown notable productivity or influence in molding the discourse on this specific subject. The *International Journal of Interactive Mobile Technologies* is identified as the predominant source within the dataset, with a total of seven articles. The significant impact of this magazine indicates that it serves as a prominent avenue for scholarly investigations pertaining to mobile apps and big data analytics within the context of higher education. The primary emphasis on interactive mobile technology is tightly aligned with the topic matter being examined, making it a crucial resource for academic involvement in this field.

In addition, the *ARPN Journal of Engineering and Applied Sciences and Sustainability* (Switzerland) both provide two papers each. Although their contribution is relatively small in comparison to the primary source, their existence suggests that study on this subject encompasses other fields, such as engineering and sustainability, emphasizing its interdisciplinary character. Also, the collection includes one article from each of the following academic journals: *ACM Transactions on Computing Education*, *Annals of Data Science*, *Cluster Computing*, *Computer Systems Science and Engineering*, *Estudios de Economia Aplicada*, *Health Information Science and Systems*, and *IEEE Access*. The sources, albeit each providing a smaller number of articles, together enhance the diversity of the knowledge base in the study subject by including many academic fields and views.

The presence of a wide range of sources, as seen in Figure 3, demonstrates the multidisciplinary character of the study subject, embracing several fields such as technology, engineering, education, economics, and health information systems. Furthermore, it can be inferred that there is a growing acknowledgement among academics and researchers across different disciplines regarding the significance of mobile apps and big data analytics in the realm of higher education. This recognition has therefore resulted in a diverse range of academic contributions on this subject matter.

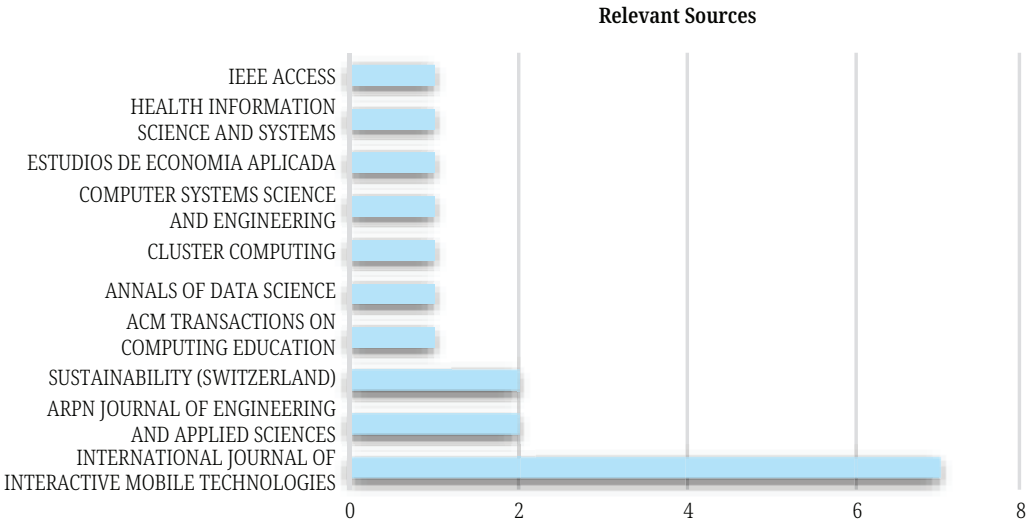

Fig. 3. Most relevant sources

4 DATA ANALYSIS AND RESULTS

The bibliometric inquiry used the Bibliometrics RStudio-4.2.1-win software program to perform a descriptive-analytic analysis. The R package, known as Bibliometrics, has been seeing a growing presence in academic literature. The present software provides R programming language users with the ability to effortlessly import an extensive bibliographic database obtained from Scopus. In accordance with a systematic bibliometric methodology, a specialized software tool called bibliometric was carefully developed using the capabilities of statistical computing methods and the flexible R programming language. The R system is widely acknowledged and frequently used as a dynamic software tool for many purposes, including data analysis and visualization, due to its reputation as the leading platform for the creation of statistical algorithms. The claim is substantiated by the scholarly study entitled "Mapping Research Trends Utilising Biblioshiny" [22]. The analysis of the data takes the form of the publishing year, author, publisher, organization, nation, and keywords utilized in the research paper.

Table 2 presents a detailed summary of the yearly citation count for the entries included within the dataset. The presented table provides significant insights into the citation patterns and trends seen in academic works across various years. In the year 2010, the average number of citations per article was 2. Nevertheless, the mean fails to provide a comprehensive representation of yearly citation trends since just a single article was published in that particular year. The average number of citations per year in 2010 was quite low, standing at 0.14. Additionally, the citable year's metric reveals that these papers received citations for a considerable duration after their initial publication, with a span of 14 years. In the year 2013, the average number of citations per article stayed constant at 20, with an average rate of 1 citation per year. The sustained citation rate seen over a span of 11 years (referred to as citable years) indicates that the research produced during that period had an enduring influence on the respective area.

In the year 2015, the average number of citations per article was 4, which corresponds to an average of 0.44 citations each year. The somewhat lower yearly citation rate observed may suggest that the research published in the current year had a

comparatively lesser long-term impact in comparison to the publications from 2013. The year 2016 is notable for having an average of 10.67 citations per article and an average of 1.33 citations per year. The papers of the current year have consistently received citations over a period of 8 years, indicating their enduring significance. In addition, in 2018, there was a notable rise in the average number of citations per article, reaching a value of 75.33. Furthermore, the yearly average of citations per year was 12.55. Nevertheless, the number of citable years decreased to 6, suggesting that the influence of these pieces was more focused in the years immediately after their publication.

Moreover, it was observed in 2019 that the mean number of citations per article was 6.57, and the mean number of citations received per year was discovered to be 1.31. Subsequently, the citable years' metric was reduced to a span of five years, signifying a notable and expeditious decrease in the influence and significance of these written works. In the year 2020, there was a notable mean of 20.43 citations per article, although the annual average number of citations was 5.11. The discovery indicates that the research undertaken in the current year has had a noteworthy and lasting impact, as seen by the total number of citable years, which totals 4. Furthermore, it is noteworthy that in the year 2021, the mean number of citations per article was recorded at 5.09, while the mean number of citations per year amounted to 1.70. The citable years' data indicates a decrease in the length of effect to three, implying a somewhat shorter period of influence. In 2022, the mean citation count per article was 12, leading to an annual average of 6 citations. The citable years' metric was then reduced to 2, indicating that the impact of these articles was mostly concentrated within a limited timeframe. In the year 2023, the average number of citations per article was one, and the yearly average citation rate was one citation per year. This discovery aligns with the notion of citable years of 1, which suggests that the papers released in that specific year have just recently begun to get citations.

Overall, Table 2 provides a thorough examination of the annual citation patterns seen in the dataset, highlighting variations in the impact of citations and the duration of their effects across different publication years. The data illustrates that some years had consistent citation patterns, while others displayed a more concentrated or transient impact. These trends possess the capacity to provide valuable information pertaining to the intellectual impact and reception of research within the given field for a certain duration.

Table 2. Annual citation per year

Year	Mean TC Per Art	N	Mean TC Per Year	Citable Years
2010	2	1.00	0.14	14
2013	20	1.00	1.82	11
2015	4	1.00	0.44	9
2016	10.67	3.00	1.33	8
2018	75.33	3.00	12.55	6
2019	6.57	7.00	1.31	5
2020	20.43	7.00	5.11	4
2021	5.09	11.00	1.70	3
2022	12	4.00	6.00	2
2023	1	4.00	1.00	1

In addition, Table 3 presents a systematic hierarchy of sources organized according to their frequency of reference within the dataset. The use of this table is crucial for the purpose of finding the preeminent and extensively referenced journals within the domain of the "Brad Ford Law" field of study. Every source is accompanied by its corresponding rank, citation frequency, cumulative frequency, and classification into distinct zones. With 7 citations, the *International Journal of Interactive Mobile Technologies* tops the list. The aforementioned publication demonstrates a notable prominence within the dataset, indicating its substantial impact on the field of research. The placement of the object in "Zone 1" signifies its predominant significance within the study framework. On the other hand, the *ARPN Journal of Engineering and Applied Sciences* and *Sustainability* (Switzerland) holds the second and third rankings, respectively, with two citations apiece. The sources are further categorized inside "Zone 1," signifying their pertinence and significance within the field.

The sources, namely *ACM Transactions on Computing Education*, *Annals of Data Science*, and *Cluster Computing*, have been referenced singularly and have been classified as belonging to "Zone 1," signifying their contribution to the study but with a somewhat lower citation frequency. As we go through the inventory, the sources are categorized into "Zone 2" and "Zone 3," denoting their secondary and tertiary degrees of significance within the investigation. The sources, such as *Computer Systems Science and Engineering*, *IEEE Access*, *Journal of Healthcare Engineering*, and others, have garnered a relatively lower number of citations. However, they still provide valuable contributions to the broader academic discourse. Table 3 serves as a great resource for comprehending the influential sources that have contributed significantly to the development of the "Brad Ford Law" research. This approach not only emphasizes the most significant sources but also organizes them into distinct categories, establishing a clear hierarchy of significance within the citation landscape. This information is crucial for scholars who want to delve into deeper insights or concentrate on certain journals and articles that have had a substantial impact on the subject.

Table 3. Core sources by Bradford Law

Sources	Rank	Freq	Cum Freq	Zone
International Journal of Interactive Mobile Technologies	1	7	7	Zone 1
ARPN Journal of Engineering and Applied Sciences	2	2	9	Zone 1
Sustainability (Switzerland)	3	2	11	Zone 1
ACM Transactions on Computing Education	4	1	12	Zone 1
Annals of Data Science	5	1	13	Zone 1
Cluster Computing	6	1	14	Zone 1
Computer Systems Science and Engineering	7	1	15	Zone 2
Estudios De Economia Aplicada	8	1	16	Zone 2
Health Information Science and Systems	9	1	17	Zone 2
IEEE Access	10	1	18	Zone 2
IEEE Internet of Things Journal	11	1	19	Zone 2
International Journal of Business Science and Applied Management	12	1	20	Zone 2
International Journal of Computing and Digital Systems	13	1	21	Zone 2

(Continued)

Table 3. Core sources by Bradford Law *(Continued)*

Sources	Rank	Freq	Cum Freq	Zone
International Journal of Distributed Systems and Technologies	14	1	22	Zone 2
International Journal of Emerging Technologies in Learning	15	1	23	Zone 2
International Journal of Engineering and Technology (UAE)	16	1	24	Zone 2
International Journal of Grid and Distributed Computing	17	1	25	Zone 2
International Journal of Innovative Technology and Exploring Engineering	18	1	26	Zone 2
International Journal of System Assurance Engineering and Management	19	1	27	Zone 2
Journal of Advances in Management Research	20	1	28	Zone 2
Journal of Food Quality	21	1	29	Zone 2
Journal of Healthcare Engineering	22	1	30	Zone 3
Journal of Information Systems Education	23	1	31	Zone 3
Journal of Internet Technology	24	1	32	Zone 3
Journal of the Operational Research Society	25	1	33	Zone 3
Multimodal Technologies and Interaction	26	1	34	Zone 3
Peer-To-Peer Networking and Applications	27	1	35	Zone 3
Scalable Computing	28	1	36	Zone 3
Science of the Total Environment	29	1	37	Zone 3
Smart Learning Environments	30	1	38	Zone 3
Strategic Direction	31	1	39	Zone 3
Technology, Pedagogy and Education	32	1	40	Zone 3
Ubiquitous Learning	33	1	41	Zone 3
Worldwide Hospitality and Tourism Themes	34	1	42	Zone 3

Furthermore, in Figure 4, the word cloud visualization illustrates the prominent themes and topics that are commonly encountered in the “Brad Ford Law” research, offering valuable insights into the subject matter. Word clouds are graphical representations that highlight words depending on their frequency, enabling us to discern the most significant and often occurring subjects. The phrase “big data” emerges as the most salient term in the word cloud, occupying a prominent position with a frequency of 14 occurrences. This statement underscores the primary emphasis of the research on big data and its ramifications within the framework of higher education establishments. The word “data analytics” is prominently included in the text, appearing a total of 11 times. This emphasizes the need to use data analysis methodologies to comprehensively comprehend and efficiently use huge amounts of data.

In addition, the term “mobile applications” appears often, suggesting the significance of mobile technology and its uses within the scope of the research. This observation implies a significant correlation between big data and mobile apps, perhaps within the realm of higher education. The term ‘artificial intelligence’ is employed six times, underscoring its pivotal role in data analysis and its potential to drive

insights in higher education and various other domains. The occurrence of the terms "advanced analytics," "Internet of Things," "mobile computing," and "data handling" is seen five times each, hence emphasizing the diverse and intricate characteristics of data-driven technologies and their wide-ranging use across several fields. The concept of "disruptive technology" and its implications for "higher education institutions" are recurrently discussed, underscoring the profound influence that new technologies such as big data and AI have on the landscape of higher education.

On the other hand, the terms "algorithm," "big data applications," "cloud computing," "data mining," "disaster management," "disasters," "higher education," "human," "internet," and "mobile application" are each mentioned three times in the given text. The keywords include supplementary topics and ideas that add to the comprehensive framework of the research. In brief, Figure 4 presents a graphical depiction of the phrases that appear most often in the dataset, providing significant insights into the fundamental themes and ideas that form the basis of the "Brad Ford Law" study. This paper elucidates the interdependencies of big data, data analytics, mobile apps, artificial intelligence, and other associated ideas within the realm of higher education institutions. The use of this visualization facilitates the expeditious identification of the principal areas of emphasis and furnishes a structured framework for comprehending the major concepts and discoveries of the investigation.

Fig. 4. Word cloud

In addition, Table 4 provides a complete analysis of theme clusters, including a quantitative evaluation of their properties within data-driven higher education research. These metrics provide useful insights into the relative significance and concentration of each thematic cluster, therefore illuminating the core topics and their prominence throughout the study. The theme cluster centered on "big data" is seen to be a prominent focus point, exhibiting a notably high Callon centrality value of 12.113 and a Callon density value of 80.11. The measurements presented demonstrate that "big data" occupies a major and highly interrelated role within the field of research, therefore establishing it as a fundamental subject.

Likewise, the concept of 'cloud computing' holds notable importance, as indicated by a Callon centrality value of 2.961 and a Callon density value of 153.08.

The high density of this cluster indicates a strong emphasis on the issue within the study, while its centrality highlights its importance. The concept of "mobile computing" is noteworthy, as indicated by its Callon centrality score of 1.25 and Callon density score of 61.67. These metrics demonstrate that mobile computing is a significant and interrelated thematic cluster. Furthermore, the subject cluster focused on "higher education" holds a prominent position, as evidenced by its Callon centrality score of 0.917 and a Callon density value of 50. The recurring motif observed in this research pertains to higher education institutions, which constitute a core cluster.

The theme clusters of "big data analytics," "higher education institutions," and "big data analytics" exhibit moderate centrality and density. These clusters enhance the multidimensionality of the study by investigating interconnected facets of big data and its use in the context of higher education. The term "diagnosis" denotes a theme cluster that exhibits limited centrality and density, indicating a smaller scope within the field of inquiry. Moreover, the concepts of "big data" and "cloud computing" have the highest rankings in terms of both centrality and density, underscoring their substantial significance. The subject matter of "mobile computing" has a prominent status, signifying its substantial presence within the realm of academic inquiry.

In summary, Table 4 presents a comprehensive evaluation of the topic clusters in the study, assessing their centrality, density, and ranking. The measurements provide insight on the core notions of "big data" and "cloud computing," which have major relevance in the field of study. Moreover, the graphic adeptly illustrates the extensive breadth of the study by admitting interrelated topics such as "higher education" and "diagnosis." The provided analytical framework provides a systematic method for understanding the thematic landscape, aiding researchers in comprehending the significance and interrelationships of key issues within the study.

Table 4. Thematic clusters

Cluster	Callon Centrality	Callon Density	Rank Centrality	Rank Density	Cluster Frequency
higher education	0.916666667	50	6	2	5
cloud computing	2.961111111	153.0864198	8	9	22
mobile computing	1.25	61.66666667	7	4	9
big data	12.11333333	80.1098251	9	8	55
big data analytic	0.5	62.5	3.5	5.5	4
higher education institutions	0.541666667	62.5	5	5.5	8
big data analytics	0.5	75	3.5	7	4
diagnosis	0	50	1.5	2	2

Finally, the topic of research was chosen as the keyword plus during the building of the thematic map and examination of its progression [23]. To achieve the best results, the word count was limited to 50 to 250, allowing for thorough research [24] [25]. The thematic map assigned two labels to each cluster, with a minimum cluster frequency of 15 per thousand documents set as the threshold. The size of the labels was modified to 0.03 to improve the visibility of the theme map. It is noteworthy that the units of size on the map are relative and determined by the tool itself, where a value of 1 represents the biggest size.

The final thematic map is shown in Figure 5, wherein it is organized based on the dimensions of density and centrality. The thematic map may be categorized into

four separate quadrants, including developing or declining topics, motor themes, basic themes, and specialist themes. The thematic map is segmented into quadrants by dashed lines along the horizontal and vertical axes.

In the context of this thematic map, the categories of "higher education," "application programs," and "mobile computing" are classified as foundational or fundamental topics, signifying essential components within the study domain. On the other hand, the concept of "water quality" is positioned inside the quadrant that represents developing or declining themes, indicating its dynamic nature or decreasing significance within the field of study.

The niche topic quadrant has important components such as "big data analytics," "information management," "higher education institutes," and "students." In the study context, the terms "cloud computing," "big data," and "data analytics" are situated in the motor topic quadrant, indicating their significant and evolving responsibilities.

Figure 5 provides a graphical depiction of the thematic map, organized according to measures of density and centrality. The categorization of topics into four separate quadrants effectively allows for the examination of their relative relevance and the development of their position within the research. The use of this map facilitates the understanding of the thematic dynamics and interconnections, making it a helpful instrument for researchers delving into the comprehensive examination of the study's overarching themes and patterns.

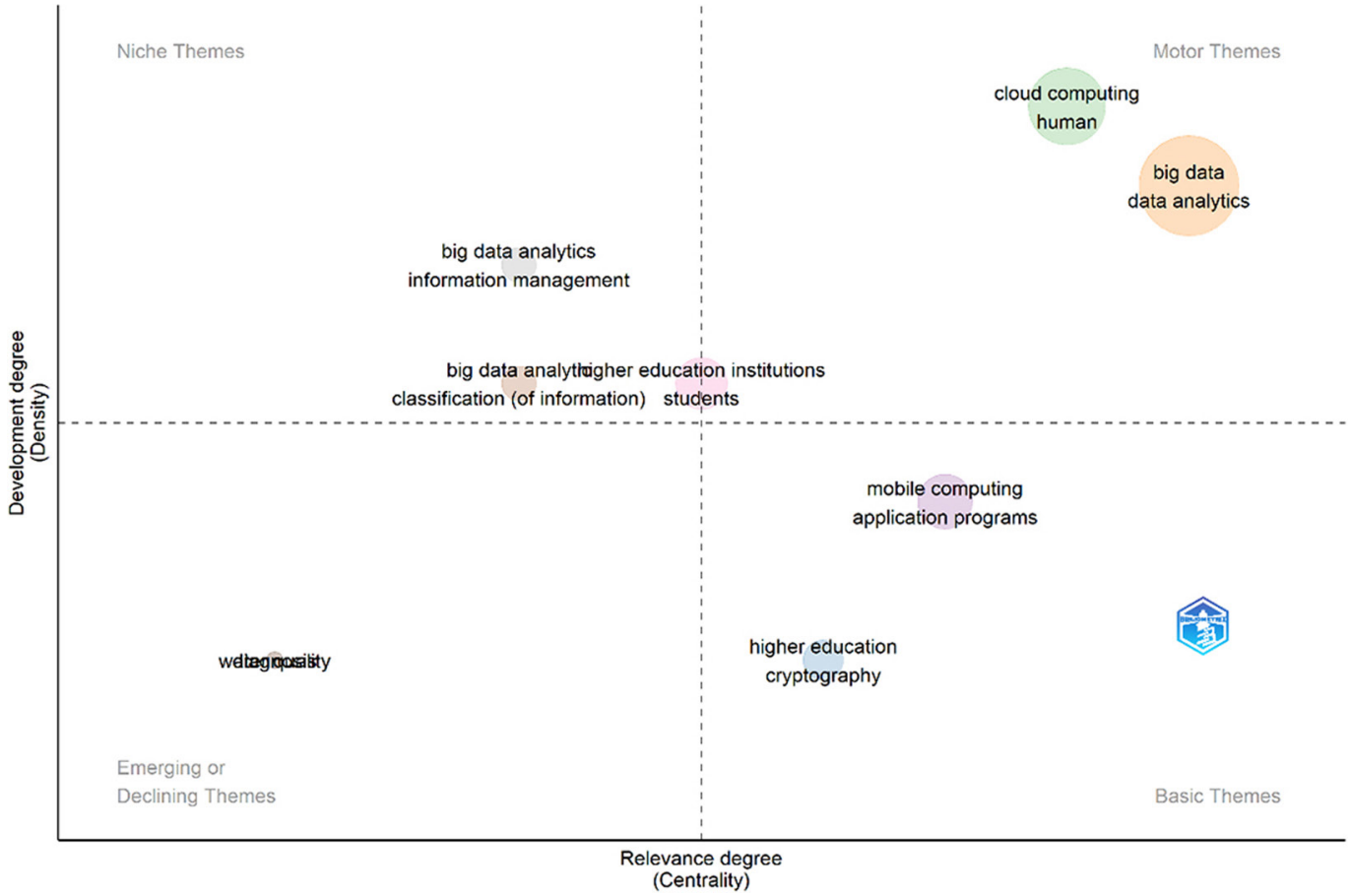

Fig. 5. Thematic map

5 CONCLUSION AND FUTURE AGENDA

In today's quickly expanding educational scene, the incorporation of technology has become a key aspect in molding the future of higher education [26]. Big data analytics and mobile-driven processes are seen as significant drivers of innovation and informed decision-making within the realm of disruptive technology [27]. In this study, we have engaged in a thorough examination of the study aim and a collection of relevant research inquiries related to the topic of "Empowering Higher Education: A Big Data Analytics Approach to Mobile-Driven Decision-Making." The primary research aim was to investigate the potential of big data analytics to enhance decision-making processes inside higher education institutions, with a specific focus on the use of mobile technology.

The authors thoroughly examine the many dimensions involved in the use of big data analytics in higher education, including not only the advantages it offers but also the obstacles, ethical implications, and recommended approaches. The inquiries include a wide range of topics, spanning from the pragmatic use of big data analytics in the academic sphere to its influence on student engagement, retention, and academic performance. The analysis of themes has shown the key topics and factors pertaining to this area of study. The investigation has been conducted on the frequency of phrases such as "big data," "cloud computing," "mobile computing," and "higher education" within the dataset, emphasizing their importance in the realm of mobile-centric decision-making in the academic domain.

In addition, we have conducted an analysis of tables and figures that provide significant insights into the patterns of citations, clusters of themes, and the distribution of subjects depending on their density and centrality. The use of visualizations serves to enhance the comprehension of the study environment and its dynamics, providing a more profound knowledge of the interconnections among significant subjects. Furthermore, the study purpose and issues described in this discourse provide a foundation for a thorough investigation of the revolutionary capacity of big data analytics in the realm of higher education. In the current era dominated by mobile technology, institutions of higher education can leverage data-driven insights to adapt, innovate, and empower themselves, enabling them to make well-informed choices that enhance the educational experience and ultimately benefit students [28] [29]. The ongoing influence of technology on the educational domain has led to the emergence of several possibilities for academia to adapt, flourish, and effectively address the evolving requirements of learners in the digital era via the convergence of big data analytics and mobile technologies.

6 REFERENCES

[1] U. Awan, S. Shamim, Z. Khan, N. U. Zia, S. M. Shariq, and M. N. Khan, "Big data analytics capability and decision-making: The role of data-driven insight on circular economy performance," *Technol. Forecast Soc. Change.*, vol. 168, p. 120766, 2021. https://doi.org/10.1016/j.techfore.2021.120766

[2] F. H. Yu *et al.*, "Concurrence of anomalous Hall effect and charge density wave in a superconducting topological kagome metal," *Phys. Rev. B.*, vol. 104, no. 4, p. L041103, 2021. https://doi.org/10.1103/PhysRevB.104.L041103

[3] B. Daniel, "Big data and analytics in higher education: Opportunities and challenges," *British Journal of Educational Technology*, vol. 46, no. 5, pp. 904–920, 2015. https://doi.org/10.1111/bjet.12230

[4] R. Yu, Q. Li, C. Fischer, S. Doroudi, and D. Xu, "Towards accurate and fair prediction of college success: Evaluating different sources of student data," *International Educational Data Mining Society*, 2020. [Online]. Available: https://facctconference.org/. [Accessed: Sep. 04, 2023].

[5] N. M. Indiani, "Unleashing the power of data: Exploring the transformative effects of data-driven strategies on personalized learning experiences and student mastery," *Eurasian Journal of Educational Research*, vol. 102, no. 102, pp. 301–322, 2022. https://doi.org/10.14689/ejer.2022.102.016

[6] C. Liu, P. Zhang, and X. Xu, "Literature review of digital twin technologies for civil infrastructure," *Journal of Infrastructure Intelligence and Resilience*, vol. 2, no. 3, p. 100050, 2023. https://doi.org/10.1016/j.iintel.2023.100050

[7] A. Z. Faroukhi, I. El Alaoui, Y. Gahi, and A. Amine, "Big data monetization throughout big data value chain: A comprehensive review," *J. Big Data.*, vol. 7, no. 1, pp. 1–22, 2020. https://doi.org/10.1186/s40537-019-0281-5

[8] E. Riley, N. Capps, N. Ward, L. McCormack, and J. Staley, "Maintaining academic performance and student satisfaction during the remote transition of a nursing obstetrics course to online instruction," *Online Learning*, vol. 25, no. 1, pp. 220–229, 2021. https://doi.org/10.24059/olj.v25i1.2474

[9] F. Conte and A. Siano, "Data-driven human resource and data-driven talent management in internal and recruitment communication strategies: An empirical survey on Italian firms and insights for European context," *Corporate Communications*, vol. 28, no. 4, pp. 618–637, 2023. https://doi.org/10.1108/CCIJ-02-2022-0012

[10] M. A. Ashaari, K. S. D. Singh, G. A. Abbasi, A. Amran, and F. J. Liebana-Cabanillas, "Big data analytics capability for improved performance of higher education institutions in the Era of IR 4.0: A multi-analytical SEM & ANN perspective," *Technol. Forecast Soc. Change.*, vol. 173, p. 121119, 2021. https://doi.org/10.1016/j.techfore.2021.121119

[11] S. A. Argyroudis *et al.*, "Digital technologies can enhance climate resilience of critical infrastructure," *Clim. Risk Manag.*, vol. 35, p. 100387, 2022. https://doi.org/10.1016/j.crm.2021.100387

[12] D. Zhou, S. Liu, and S. Grassini, "Shaping the future of education: Exploring the potential and consequences of AI and ChatGPT in educational settings," *Education Sciences,* vol. 13, no. 7, p. 692, 2023. https://doi.org/10.3390/educsci13070692

[13] S. R. Talpur *et al.*, "Improving opportunities in supply chain processes using the internet of things and blockchain technology," *International Journal of Interactive Mobile Technologies,* vol. 17, no. 8, pp. 23–38, 2023. https://doi.org/10.3991/ijim.v17i08.39467

[14] I. Mustapha, M. Ali, N. Khan, and H. Sikandar, "The impact of industry 4.0 on innovative organisations, a thematic review using the PRISMA statement 2020," *International Journal of Interactive Mobile Technologies,* vol. 17, no. 9, pp. 88–105, 2023. https://doi.org/10.3991/ijim.v17i09.39465

[15] A. Alam, "Possibilities and apprehensions in the landscape of artificial intelligence in education," in *International Conference on Computational Intelligence and Computing Applications (ICCICA)*, 2021, pp. 1–8. https://doi.org/10.1109/ICCICA52458.2021.9697272

[16] S. Akgun and C. Greenhow, "Artificial intelligence in education: Addressing ethical challenges in K-12 settings," *AI and Ethics*, vol. 2, pp. 431–440, 2022. https://doi.org/10.1007/s43681-021-00096-7

[17] T. Susnjak, G. S. Ramaswami, and A. Mathrani, "Learning analytics dashboard: A tool for providing actionable insights to learners," *International Journal of Educational Technology in Higher Education*, vol. 19, no. 1, pp. 1–23, 2022. https://doi.org/10.1186/s41239-021-00313-7

[18] S. E. Bibri, "The social shaping of the metaverse as an alternative to the imaginaries of data-driven smart cities: A study in science, technology, and society," *Smart Cities,* vol. 5, no. 3, pp. 832–874, 2022. https://doi.org/10.3390/smartcities5030043

[19] M. Khan, N. Khan, S. Begum, and M. I. Qureshi, "Digital future beyond pandemic outbreak: Systematic review of the impact of COVID-19 outbreak on digital psychology," *Foresight*, 2023. https://doi.org/10.1108/FS-02-2021-0044

[20] A. F. Abbas, N. A. Qureshi, N. Khan, R. Chandio, and J. Ali, "The blockchain technologies in healthcare: Prospects, obstacles, and future recommendations; lessons learned from digitalization," *International Journal of Online & Biomedical Engineering*, vol. 18, no. 9, pp. 144–159, 2022. https://doi.org/10.3991/ijoe.v18i09.32253

[21] Y. Vaicondam, H. Sikandar, S. Irum, N. Khan, and M. I. Qureshi, "Research landscape of digital learning over the past 20 years: A bibliometric and visualisation analysis," *International Journal of Online and Biomedical Engineering*, vol. 18, no. 8, pp. 4–22, 2022. https://doi.org/10.3991/ijoe.v18i08.31963

[22] B. Buyamin *et al.*, "The influence of war and global economy on article publication (Bibliometric Analysis using Biblioshiny-R)," *Research Square*, preprint, 2023. https://doi.org/10.21203/rs.3.rs-2680363/v1

[23] M. J. Cobo, A. G. López-Herrera, E. Herrera-Viedma, and F. Herrera, "An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field," *J. Informetr.*, vol. 5, no. 1, pp. 146–166, 2011. https://doi.org/10.1016/j.joi.2010.10.002

[24] S. Sengupta and A. Vaish, "A study on social media and higher education during the COVID-19 pandemic," *Univers. Access Inf. Soc.*, vol. 1, pp. 1–23, 2023. https://doi.org/10.1007/s10209-023-00988-x

[25] X. Chen, Y. Lun, J. Yan, T. Hao, and H. Weng, "Discovering thematic change and evolution of utilizing social media for healthcare research," *BMC Med. Inform. Decis. Mak.*, vol. 19, no. 2, pp. 39–53, 2019. https://doi.org/10.1186/s12911-019-0757-4

[26] D. Horváth *et al.*, "Will interfaces take over the physical workplace in higher education? A pessimistic view of the future," *Journal of Corporate Real Estate*, vol. 24, no. 2, pp. 108–123, 2022. https://doi.org/10.1108/JCRE-10-2020-0052

[27] Y. Sun, C. Liu, and C. Zhang, "Mobile technology and studies on transport behavior: A literature analysis, integrated research model, and future research agenda," *Mobile Information Systems*, vol. 2021, 2021. https://doi.org/10.1155/2021/9309904

[28] H. Sikandar, Y. Vaicondam, N. Khan, M. I. Qureshi, and A. Ullah, "Scientific mapping of industry 4.0 research: A bibliometric analysis," *International Journal of Interactive Mobile Technologies*, vol. 15, no. 18, pp. 129–147, 2021. https://doi.org/10.3991/ijim.v15i18.25535

[29] I. Mustapha, N. Khan, M. I. Qureshi, A. A. Harasis, and N. T. Van, "Impact of industry 4.0 on healthcare: A systematic literature review (SLR) from the last decade," *International Journal of Interactive Mobile Technologies*, vol. 15, no. 18, pp. 116–128, 2021. https://doi.org/10.3991/ijim.v15i18.25531

7 AUTHORS

Ishamuddin Mustapha, Malaysian Institute of Industrial Technology (MITEC), Universiti Kuala Lumpur, Kuala Lumpur, Malaysia (E-mail: Ishamuddin@unikl.edu.my).

Vichayanan Rattanawiboonsom, Faculty of Business, Economics, and Communications, Naresuan University, Phitsanuloke Thailand (E-mail: vichayananr@nu.ac.th).

Ruankwan Intanon, Faculty of Business, Economics, and Communications, Naresuan University, Phitsanuloke Thailand.