

Forecasting the Future: Exploring Advanced Trends in Digital Education

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Abstract— A common and reliable way to look at and analyse a lot of scientific data is through bibliometric analysis. It helps us understand how a certain field has changed over time and shines a light on new areas in that field. But its use in digital education research is still new and, in many cases, not very well-developed. So, we will try to give an overview of the bibliometric method, with a focus on its different techniques, as well as step-by-step instructions that can be used to do bibliometric analysis correctly and with confidence. In order to do this, we also explain when and how bibliometric analysis should be used in comparison to similar methods like meta-analysis and systematic literature reviews. Overall, This analysis may also highlight new and emerging areas of research and provide insights into the direction of digital education in the future .

Index Terms—Bibliometric analysis; Science mapping; Performance analysis; Co-citation analysis; Citation analysis; Bibliographic coupling; Co-word analysis.

I. INTRODUCTION

Digital education, also known as e-learning or online learning, refers to the use of digital technologies to deliver educational content and facilitate learning. Digital education can take many forms, such as online courses, webinars, virtual classrooms, and educational apps. Digital education has become increasingly popular in recent years due to the growth of the internet and the widespread use of digital devices such as smartphones, tablets, and computers. Digital education offers several benefits, including greater flexibility and accessibility for learners, the ability to learn at one's own pace, and the ability to access a wide range of educational resources from anywhere in the world. However, digital education also presents some challenges, such as the need for learners to have access to reliable internet connections and digital devices, the potential for distraction and reduced motivation, and the need for effective strategies to assess learning outcomes in a digital environment .

Bibliometric analysis is a method of analyzing and quantifying patterns of publication and citation in a particular field of study. In the context of digital education, bibliometric analysis can be used to identify trends and patterns in research related to digital education, such as the most frequently cited authors, the most common research topics, and the most influential publications. Here are some potential uses of bibliometric analysis in the field of digital education: Bibliometric analysis can help identify emerging research trends in digital education, such as new technologies

or teaching methods that are gaining popularity among researchers. Bibliometric analysis can be used to evaluate the impact of individual research papers or authors in the field of digital education. This can help researchers, educators, and policymakers identify influential research and prioritize areas for further study .

In 1992, seminal paper written by A.C. Boynton *et.al.* ([1]) titled 'The post-fordist transformation: information technology and organizational change' This study blends qualitative field research with survey-based longitudinal data analysis to better comprehend the role of IT in post-Fordist transition. A bibliometric analysis can expose the leading researchers in a subject, identify the most influential publications, and explain the topic's evolution through time.

Therefore, this study conducts a comprehensive bibliometric analysis of the literature on digital education in an effort to address the following questions:

- What are the most cited works on value digital education, and how have they evolved over time?
- Who are the leading writers, journals, institutions, and nations that have contributed the most to the topic of value digital education? Why do they have so much sway, exactly?
- What are the new areas of research in the field of digital education?

This study answers these issues and makes the following contributions to the field of digital education. To begin, this research would aid the digital education hypothesis by highlighting the most prominent trends in the field. The second goal of this research is to help managers and practitioners better understand value of digital education so that they may use it as a strategic intervention in their own enterprises.

After a brief introduction to the digital education literature, we describe the research approach taken in this investigation. Following the bibliometric study results is a detailed discussion of the most prominent trends in the growing subject of value digital education. Implications, restrictions, and suggestions for future study are discussed in the concluding section of the work.

II. UNDERSTANDING DIGITAL EDUCATION

Digital education refers to the use of technology and digital tools to enhance the teaching and learning experience. The value of digital education lies in its ability to provide learners with access to a wealth of information, resources, and learning opportunities that were previously unavailable or limited. Some of the benefits of digital education include; Digital education allows learners to access educational materials at any time, from anywhere, and at their own pace. This flexibility is particularly useful for working professionals or individuals who have other commitments that make it difficult to attend traditional classroom-based courses.

Digital education can be tailored to the individual needs and preferences of learners. For example, learners can choose to focus on specific topics or areas of interest, and digital tools can be used to adapt the learning experience to their learning style. Digital education provides opportunities for learners to interact with the material and with each other in new ways. For example, online discussion forums and collaborative tools allow learners to engage in discussions and group projects. Digital education can be more cost-effective than traditional classroom-based courses, as there are often no expenses associated with physical classroom space, textbooks, or other materials. Digital education can provide access to educational opportunities for individuals who may not have had access otherwise, such as those living in remote or underserved areas or individuals with disabilities.

III. DATA COLLECTION

The flow chart presents the step-wise procedure followed for the collection of data related to digital education. In the first step, the keywords "Digital Education" and "Learning" were used to gather 1073 documents. In the second step, the search was limited to emerging trends in digital education, resulting in 355 documents. The third step involved limiting the search to the period between 1992-2022 and excluding documents of 2023, resulting in 343 documents. In the fourth step, the search was limited to articles, book chapters, conference papers, and reviews, which resulted in 313 documents. The fifth step involved limiting the search to the submission final stage, which resulted in 307 documents. Finally, in the sixth step, data cleaning was performed by removing duplicate documents, resulting in a final set of 292 documents.

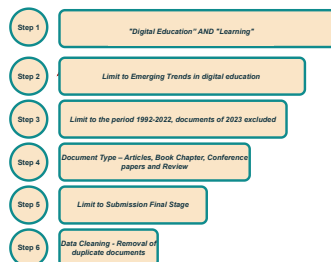


Fig. 1. Step-wise procedure of collection of data

IV. RESULT

A. Most cited documents

This table I provides a list of the 20 most cited documents in the digital education literature, along with their rank, document title, and number of citations. The citation counts were retrieved from a database of scholarly literature and reflect the number of times each document has been cited in other academic publications. The table is useful for researchers and practitioners in the field of digital education who may be interested in understanding the most influential and impactful literature in the field. The table can help guide future research and inform decisions about which resources to consult when seeking information about specific topics related to digital education .

It is important to note that the table I includes documents with a range of topics related to digital education, including cultural heritage, mental health, financial literacy, language education, and entrepreneurship education. The range of topics reflects the interdisciplinary nature of digital education and highlights the diverse perspectives and approaches that exist in the field. The table also shows that some documents have been cited significantly more often than others. For example, the document ranked at number one, "A survey of augmented, virtual, and mixed reality for cultural heritage," has been cited 393 times, while the document ranked at number 20, "Digital education governance: An introduction," has been cited 52 times. This suggests that some topics or areas of research within digital education have received more attention and interest from scholars than others.

TABLE I: Most cited documents in the digital education literature

Rank	Document	Cite
1	A survey of augmented, virtual, and mixed reality for cultural heritage [2]	393
2	Sodium-Ion Battery Materials and Electrochemical Properties Reviewed [3]	366
3	What is eHealth (4): A scoping exercise to map the field [4]	319
4	Digital technology for treating and preventing mental disorders in low-income and middle-income countries: a narrative review of the literature [5]	235
5	Financial literacy: A systematic review and bibliometric analysis [6]	152
6	Web 2.0, synthetic immersive environments, and mobile resources for language education [7]	134
7	Is Online Health Activity Alive and Well or Flatlining? Findings from 10 Years of the Health Information National Trends Survey [8]	125
8	Teleneurology and mobile technologies: The future of neurological care [9]	121
9	Women's health and the internet: Understanding emerging trends and implications [10]	107
10	Digital technology and the contemporary university: Degrees of digitization [11]	92

B. Most relevant author

Table II lists the most relevant authors in terms of total citations received. The table includes the author's name, year of publication, and the number of citations received. The data is useful for identifying the leading scholars in a particular

field based on the impact of their work, as measured by the number of times their publications have been cited by other researchers. The table indicates that Bekele m.k. (2018) is the most cited author with 393 citations, followed closely by Chayambuka K. (2018) with 366 citations and Pagliari C. (2005) with 319 citations. The other authors in the list have also contributed significantly to their respective fields, with the number of citations ranging from 75 to 235. The data in the table can be used by researchers to identify the most influential authors and their contributions to a particular field, providing valuable insights into the state of research in that area.

TABLE II: Most relevant authors (in terms of total citations received)

S.R	Document	Citations
1	Bekele m.k. (2018)	393
2	Chayambuka K. (2018)	366
3	Pagliari C. (2005)	319
4	Naslund J.A. (2017)	235
5	Sykes J.M. (2008)	152
6	Prestin A. (2015)	134
7	Dorsey E.R. (2018)	125
8	Pandey S.K. (2003)	121
9	Selwyn N. (2014)	107
10	Bhargava R. (2016)	92
11	Wymbs C. (2011)	92
12	Ratten V. (2021)	88
13	Hsin C.-T. (2014)	87
14	Benzing V. (2018)	81
15	Mith (2017)	75

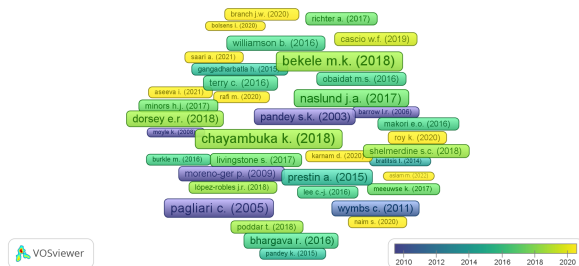


Fig. 2. Caption for the image

C. Keywords

The table III above shows the occurrence of twenty different keywords in a scientific context. The keywords were selected based on their relevance to current trends and issues in education and technology. The first four keywords, Artificial Intelligence, Augmented Reality, Bibliometric Analysis, and Big Data, are related to emerging technologies that have the potential to transform education and other fields. Covid-19, Curricula, and Digital Storage are keywords that have gained significance due to the ongoing pandemic and the shift to online and hybrid learning. Digital Technologies, Digital Transformation, and Digitalization are keywords that describe the broader trend towards using technology to enhance and improve various aspects of education and other fields.

E-Learning and Education are two keywords that are central to the study of education and the use of technology in education. Educational Technology is a related keyword that focuses specifically on the tools and technologies used in education. Emerging Technologies and Emerging Trends are two keywords that capture the rapid pace of technological change and its impact on various fields, including education. Engineering Education and Higher Education are two keywords that highlight the importance of education in shaping and preparing the workforce for the future.

The last three keywords, Human, Humans, and Industry 4.0, are related to the social and economic implications of emerging technologies and their impact on human society. These keywords highlight the need for a more human-centered approach to the development and implementation of technology in various fields, including education. The keywords in this table provide insight into the current trends and issues in education and technology and the challenges and opportunities that lie ahead.

TABLE III: Co-occurrence of author keywords

S.r	Keyword	Occurrences
1	Artificial Intelligence	18
2	Augmented Reality	10
3	Bibliometric Analysis	13
4	Big Data	12
5	Covid-19	14
6	Curricula	14
7	Digital Storage	14
8	Digital Technologies	20
9	Digital Transformation	18
10	Digitalization	11
11	E-Learning	54
12	Education	50
13	Educational Technology	10
14	Emerging Technologies	19
15	Emerging Trends	13
16	Engineering Education	51
17	Higher Education	24
18	Human	39
19	Humans	27
20	Industry 4.0	11

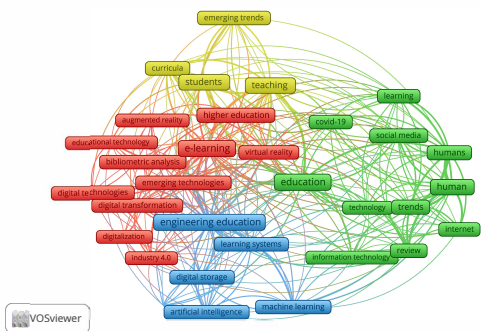


Fig. 3. Co-occurrence of author keywords

D. Most influential countries

This table IV shows the top 20 countries in terms of total citations received. The data is based on a specific set of

documents and is not representative of all fields of study or all publications. The United States is the most influential country, with 99 documents and 2008 citations. Australia and the United Kingdom are second and third, respectively, with 24 and 35 documents and 1169 and 1054 citations. The Netherlands, India, South Africa, Germany, Italy, Spain, China, Switzerland, Taiwan, Finland, Canada, and Turkey are also in the top 15 countries in terms of citations received. The Russian Federation, Sweden, Saudi Arabia, Singapore, and Greece are in the top 20 but have received fewer citations than the other countries.

It's important to note that this ranking doesn't necessarily reflect the overall scientific output or impact of these countries. The number of documents and citations can vary greatly depending on the field of study and the specific papers being analyzed.

TABLE IV: Most influential countries (in terms of total citations received)

S.r	country	documents	citations
1	United States	99	2008
2	Australia	24	1169
3	United Kingdom	35	1054
4	Netherlands	6	762
5	India	26	613
6	South Africa	14	527
7	Germany	14	498
8	Italy	6	407
9	Spain	21	216
10	China	24	170
11	Switzerland	5	135
12	Taiwan	8	115
13	Finland	5	111
14	Canada	18	101
15	Turkey	5	101
16	Russian Federation	22	75
17	Sweden	7	70
18	Saudi Arabia	6	62
19	Singapore	6	62
20	Greece	9	43

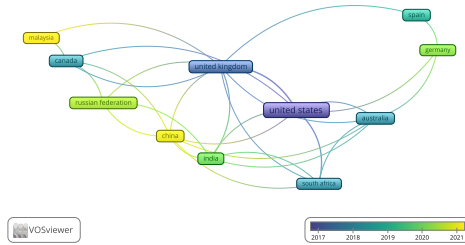


Fig. 4. Most influential countries (in terms of total citations received)

E. Corresponding author

This table V shows the number of articles, corresponding authors' countries, and some metrics related to corresponding authors' countries. The metrics include SCP (Solo Corresponding Author Publications), MCP (Multiple Corresponding Author Publications), Freq (Frequency), and

MCP Ratio (Multiple Corresponding Author Publication Ratio). The table lists the top 20 countries based on the number of corresponding authors who published in the journal. The United States (USA) had the highest number of articles with 43, followed by China with 20 articles, and the United Kingdom with 13 articles. The SCP column shows the number of articles with only one corresponding author from the listed country. The MCP column shows the number of articles with more than one corresponding author from the listed country.

The Freq column indicates the frequency of the corresponding author's country in the list of all corresponding authors for the given journal. For example, the frequency of USA is 0.128, which means that 12.8% of all corresponding authors who published in the journal were from the USA. The MCP Ratio column indicates the ratio of multiple corresponding author publications to the total number of corresponding author publications from that country. For example, the MCP Ratio for the United Kingdom is 0.462, which means that 46.2% of the publications from the United Kingdom had multiple corresponding authors.

TABLE V: Corresponding Author's Countries

Sr	Country	Articles	SCP	MCP	Freq	MCP_Ratio
1	Usa	43	34	9	0.128	0.209
2	China	20	15	5	0.06	0.25
3	United Kingdom	13	7	6	0.039	0.462
4	Spain	11	7	4	0.033	0.364
5	Canada	8	7	1	0.024	0.125
6	India	8	7	1	0.024	0.125
7	Australia	7	5	2	0.021	0.286
8	Germany	6	3	3	0.018	0.5
9	Korea	6	2	4	0.018	0.667
10	Czech Republic	4	3	1	0.012	0.25
11	Malaysia	3	2	1	0.009	0.333
12	Netherlands	3	2	1	0.009	0.333
13	Saudi Arabia	3	2	1	0.009	0.333
14	Greece	2	1	1	0.006	0.5
15	Hong Kong	2	2	0	0.006	0
16	Israel	2	1	1	0.006	0.5
17	Portugal	2	2	0	0.006	0
18	Switzerland	2	1	1	0.006	0.5
19	Austria	1	1	0	0.003	0
20	Belgium	1	0	1	0.003	1

F. Most influential countries

This table VI shows the top 20 countries in terms of total citations received. The data is based on a specific set of documents and is not representative of all fields of study or all publications. The United States is the most influential country, with 99 documents and 2008 citations. Australia and the United Kingdom are second and third, respectively, with 24 and 35 documents and 1169 and 1054 citations. The Netherlands, India, South Africa, Germany, Italy, Spain, China, Switzerland, Taiwan, Finland, Canada, and Turkey are also in the top 15 countries in terms of citations received. The Russian Federation, Sweden, Saudi Arabia, Singapore, and Greece are in the top 20 but have received fewer citations than the other countries.

It's important to note that this ranking doesn't necessarily reflect the overall scientific output or impact of these

countries. The number of documents and citations can vary greatly depending on the field of study and the specific papers being analyzed.

TABLE VI: Most influential countries (in terms of total citations received)

S.r	country	documents	citations
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2	Australia	24	1169
3	United Kingdom	35	1054
4	Netherlands	6	762
5	India	26	613
6	South Africa	14	527
7	Germany	14	498
8	Italy	6	407
9	Spain	21	216
10	China	24	170
11	Switzerland	5	135
12	Taiwan	8	115
13	Finland	5	111
14	Canada	18	101
15	Turkey	5	101
16	Russian Federation	22	75
17	Sweden	7	70
18	Saudi Arabia	6	62
19	Singapore	6	62
20	Greece	9	43

G. Clusters Co-occurrence Keywords Analysis

This table shows the co-occurrence of author keywords in the literature related to education and technology. The table includes 20 keywords that appear most frequently in the literature, ranked by the number of occurrences. The first column of the table indicates the rank of each keyword based on the number of occurrences. The second column shows the keyword itself, and the third column represents the number of times the keyword appears in the literature.

From the table, we can observe that the most frequent keyword is "E-Learning" with 54 occurrences, followed by "Education" with 50 occurrences, and "Engineering Education" with 51 occurrences. The keyword "Digital Technologies" also appears frequently with 20 occurrences, while "Industry 4.0" and "Augmented Reality" have the least number of occurrences, with 11 and 10, respectively.

Finally this table provides valuable insight into the current research trends in the intersection of digital technologies and education, and can inform future research in this area.

TABLE VII: Clusters Co-occurrence Keywords Analysis

Cluster 1 Article Child Digital Divide Female Health Care Delivery Human Humans Information Dissemination Internet Learning Male Medical Education Medical Information Mobile Technology Priority Journal Procedures Review Social Media Technology Telemedicine Trends Utilization	Cluster 2 Commerce Curricula Digital Devices E-Learning Education Education Computing Educational Technology Emerging Technologies Emerging Trends Game-Based Learning Human Computer Interaction Information Technology Investments Students Surveys Teaching Teaching and Learning Web 2.0	Cluster 3 Artificial Intelligence Augmented Reality Big Data Cloud Computing Computer aided Instruction Digital Storage Digital Technologies Employment Engineering Education Industry 4.0 Internet of Things Learning Environments Learning Systems Machine Learning Personnel Training Robotics Virtual Reality	Cluster 4 Bibliometric Analysis Covid-19 Digital Technology Digital Transformation Digitalization Educational Process Higher Education Higher Education Institutions Information and Communication Technologies Innovation Sustainability Sustainable Development World Wide Web
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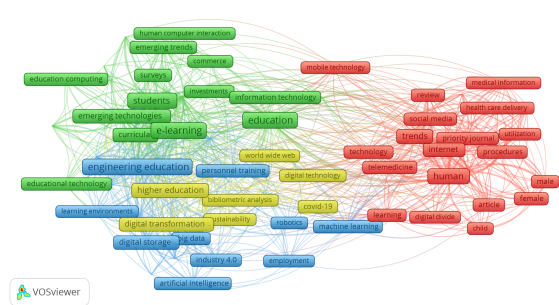


Fig. 5. Clusters Co-occurrence Keywords Analysis

H. Most influential journals (in terms of total citations received)

The table shows a ranking of journals based on the total number of citations they have received. The table includes the names of the journals, the number of documents (i.e., articles, reviews, and other research papers) they have published, and the total number of citations they have received.

At the top of the ranking is the journal "Sustainability (Switzerland)" with seven published documents and a total of 94 citations. In second place is the "International Journal of Emerging Technologies in Learning" with three published documents and 41 citations. The third place goes to the "Lecture Notes in Computer Science" with seven published documents and 41 citations. In fourth place is the "Lecture Notes in Networks and Systems" with three published documents and 11 citations. The fifth and sixth places are occupied by "Frontiers in Psychology" with three published documents and six citations and "ACM International Conference Proceeding Series" with three published documents and one citation, respectively. The ranking can be used to identify high-impact journals for researchers looking to publish their work in the field.

TABLE VIII: Journal Rankings in terms of total citations received

Journals Names	Documents	Citations
Sustainability (Switzerland)	7	94
International Journal of Emerging Technologies in Learning	3	41
Lecture Notes in Computer Science	7	41
Lecture Notes in Networks and Systems	3	11
Frontiers in Psychology	3	6
ACM International Conference Proceeding Series	3	1

V. LIMITATIONS AND FUTURE RESEARCH OPPORTUNITIES

To our knowledge, this research is one of just a handful of attempts to systematically summarise the existing literature on digital education. Despite the thoroughness, applicability, and breadth of this research, it does have several caveats that must be acknowledged. The primary shortcoming of this research is that it relied on a single database for all of its data needs. Most bibliometric studies in the literature use a single database for analysis to prevent duplication, but this can result in missing potentially essential publications that could be very useful to the field of value digital education if the databases aren't included. So, the primary weakness of this research is its reliance on a single database. Another

shortcoming is that the citation structures of the publications are not captured in their full context. Although the study provides a vivid illustration of the nature of citation structure for the literature on digital education, the study does not provide enough information to infer the context or aim of the citation structure.

The comprehensive literature evaluation employing bibliometric methods indicates some essential potential future study avenues. To begin, the digital education discussed here is limited to the fields of computer science, mathematics, business and management etc. Yet, digital education is now a fertile ground for many other academic pursuits. So, it will be important for researchers to examine the idea from a number of different perspectives in the future. Second, many more seminal works are yet to be seen in this domain, which is to be expected given the early stage and the continuing rapid expansion of this discipline. Therefore, such bibliometric studies on digital education should continue to be conducted at regular intervals of no more than five to seven years in the future. This would ensure the area remains interesting to academics in the future and fuel its relentless progress. In conclusion, there are a plethora of methods for doing a literature review utilising bibliometric analysis. Three of these analytic approaches were used in this investigation. So, other bibliometrics methods should be used in future research in order to better understand this topic .

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