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Visualizing the Evolution of Educational Technology in Higher Education: A Bibliometric Analysis using R Studio

Dr. Shreya Arora
Assistant Professor, College of Business Studies, COER University, Roorkee

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Abstract
This study offers a bibliometric analysis performed in R Studio to depict the growth of educational technology (EdTech) in higher education. The study uses bibliometric tools to track the evolution of EdTech research over time, finding major trends, influential articles, and emergent issues. This research sheds light on the transformational effect of technology in higher education pedagogy by analyzing academic literature, citation networks, and keyword mapping. The paper's goal is to contribute to a better understanding of integrating technology in teaching and learning activities inside higher education institutions by depicting ICT, EdTechs, online learning, and educational progress in higher education. The findings of this bibliometric analysis are useful for academics, educators, and policymakers looking to use educational technology's potential to improve teaching quality and student achievement.
Keywords ICT, Bibliometric Analysis, e-learning, Scopus Database, R-Studio, Higher Education

1. Introduction

The delivery of education has altered dramatically on a global scale, resulting in the rise of new learning models in which technology plays a critical role. Syllabus, pedagogy, and evaluation tools must be enhanced in the twenty-first century by utilizing ICT, EdTechs, online learning, and educational progress in higher education to its maximum potential, which both instructors and students must take use of (Navid Shaghaghi et al., 2021; Paul, 2022; Sumande and Eleanor COMENDADOR, 2016). Higher education is becoming more reliant on technology internationally due to the COVID-19 pandemic, which forced colleges to adjust by delivering online classes (Ndibalema, 2014; Kaqinari et al., 2021;Salah and Thabet, 2021) and robustness in the digital domain. (Eri *et al.*, 2021) stated that, because the EdTech integration constructs an online learning environment during lockdowns, university instructors and students must transition to digital writing (DW). While DW was a frequent type of education for children in the Z-generation, (Joseph B. Mosca *et al.*, 2019), it posed new challenges for educators in terms of increasing workload and skill building. As a result of the fast digitization of higher education, traditional paper-based texting and typing in educational settings has given way to digital screen-based messaging and typing. Furthermore, the availability of online learning is likely to increase the number and diversity of DW instances, such as annotating, chatting, typing, and e-mailing. In this confined framework for teacher professional development, issues such as the integration of ICT, EdTechs, online learning into present curricula, ICT-related curriculum adjustments, alterations in the teaching role, and grasp of learning theories were either neglected or, at most, addressed briefly. The most simple and popular teacher professional development activities in the ICT industry were those that intended to provide teachers and/or students with the skills required for ICDL certification. While these talents are required for educational technology applications, placing too much emphasis on them is erroneous and deceptive because they are commonly mistaken for a

miraculous answer. Such training experiences have no substantial impact on teaching theory or practise. Professional development efforts that are separated from learning theories and practises, curriculum, and classroom implementations will not help to change and revolutionize education. Furthermore, simply having access to and employing technology won't help a teacher who doesn't understand how pupils learn and how to fulfill their unique needs and learning styles. For example, it is ludicrous to expect a teacher to encourage cooperative learning using online communication technologies such as the Internet if they are unfamiliar with the concepts and practices of cooperative learning (Dillenbourg & Schneider 1995; Lofstrom & Nevgi, 2008). Technology is not an end in itself, it is simply a tool. Teachers must be informed about ICT, EdTechs, and online learning beyond simply utilising subject-specific software and possessing basic ICT skills, they must also understand the methods involved. This encompasses both the technical and conceptual skills that instructors require to incorporate ICT into their usual teaching activities. Teachers' attitudes toward innovation and change have a significant impact on how successfully ICT integration happens in the classroom. This demands a fundamental and continuing process of reassessing what is taught, how it is taught, and why. Adapting teaching approaches is frequently required for the optimal use of technology in education. This typically entails teachers embracing student-centered learning methods such as tailoring lessons to each student's specific learning needs, helping students shape their critical thinking as well as problem-solving abilities, and providing project-based opportunities for learners, particularly because of the use of cross-curricular thematic units. Instructors demand professional development opportunities that address these ignored difficulties, rather than merely teaching basic ICT skills disconnected from their context in the classroom (Klenin *et al.*, 2020; Makrakis, 2005). Teacher training for higher education is a dynamic feature of the international education system. The development trends in these disciplines have a significant impact on today's modern higher education teacher training programs. This essentially determines the relevance of the selected research subject and the need for a thorough review of present techniques for educating university education instructors and the digital technologies they use. (Motiwalla, 2007) information and communication technology (ICT) has increased learning, especially when combined with more learner-centered education, or convenience, where learning and interchange with the instructor may take place asynchronously at the learners' chosen speed (Palloff & Pratt, 2001). (Zhu & Kaplan, 2002) this research examines the implementation of educational technology (ET) via professional growth in higher education facilities. Higher education institutions (HEIs) have developed several strategies and staff development programs to help instructors incorporate educational technology into their teaching approaches. Whether virtual or actual, lecturers face several challenges when attempting to integrate these technologies into the classroom. The paper is organized as follows. Section 1 offers a background of the study, whereas Section 2 delves deeply into the conclusions of the prior literature review. Section 3 discussed the method of how the articles for evaluation were selected and classified. Section 4 presents the results of the bibliometric analysis conducted using R-studio and the Scopus database. Section 5 summarised the study's findings, which were followed by references in section 6.

2. Literature Review

The incorporation of advanced ICT, EdTechs, online learning into the educational system has simplified things for innovative teaching and learning techniques to take hold. A teacher's grasp of different teaching paradigms that they incorporate in their lesson plans or internet tools are part of their pedagogical awareness (Lofstrom & Nevgi, 2008; Mospan, 2023). As per the findings of (Januszewski et al., 2008; L. W. Hsu & Chen, 2019) education technology refers to the use of appropriate technical resources in a specific context to promote academic performance. Educational technology emerged from the process of organising, financing, implementing, and reviewing the classroom and all

available resources to ensure higher-quality teaching and learning (Muñoz Carril et al., 2013; Serhat Kurt, 2015). Such technologies are designed to facilitate teaching and research. The phrase "educational technology" refers to media and software that employ organised and individualised technology to give audio, visual, and video information to aid learning. Common education technologies include computers, virtual reality (VR), video games, applications, and the internet (Carras et al., 2014; Popkova et al., 2021). The use of internet and technology for instructional purposes has drastically risen in higher education institutions across the world (Buchanan et al., 2013;Sahin & Üniversitesi, 2003;Henderson and Romeo, 2015). (Khasawneh, 2015; Park et al., 2007; Charalambos Vrasidas & Gene V Glass, 2007)assert that Virtual platforms and web - based learning are increasingly popular methods of obtaining higher education. An increasing number of instructors and students use the Internet and digital tools to augment their education. How a teacher deals with technological conflict and understands the interaction of technology, society, and the individual will impact how they handle teaching technology (Hodgkinson-Williams, 2010; Lin et al., 2012). New challenges arise as a result of the present scenario of technological implementation, which necessitates the acquisition of skills. As a consequence of this interconnection, the roles of teachers and students must be altered to fit the changing conditions.(Abdullah et al., 2019; Romero Alonso et al., 2019; Gregory et al., 2015; Watson, 2001; Somekh, 2015; Sumande & Eleanor COMENDADOR, 2016) supported the argument that the main problems educators and learners have witnessed when using ICT in the classroom are, technical troubles (such as internet quality), organisational problems (such as policies, infrastructural facilities, and a lack of integration between technology, pedagogical practices, and strategy), individual problems (such as poor perceived efficacy of the technology, distinctive social dynamics) and prospective student hurdles (different social dynamic, cost, limited perceived effectiveness of technology). As these new technologies evolve, educational institutions are seeing the importance of incorporating them into the classroom. Advanced technology usage in Africa has been followed by improvements to higher education policy, assistance for ICT subscribers in academic institutions, and advancements in the cost and quality of the Internet (Morris, 2010;Okojie et al., 2006). (Muianga et al., 2019; Chigona, 2015) argue that infrastructure, attitudes, personnel development, administrative and technical support, sustainable growth, and transferability are crucial for the efficient use of ICTs.(Tarhini *et al.*, 2015) E-learning, often known as web-based learning systems, has grown substantially over the previous two decades. This expansion is due to growing rivalry among higher education institutions to attract students and suit their educational needs and ambitions. (Clark & Mayer, 2011) also to accommodate both face-to-face and remote education delivery without the limits of time and geography. (Park, 2009) a web-based learning system is regarded successful if it can recreate the classroom experience while also taking into account the demands of the students. As a result of the globalization of web-based learning systems in education, it has become necessary for educators and policymakers to understand the user acceptability of such systems to better the students' educational experiences. (Liaw & Huang,2011) the blackboard is regarded among the most effective Internet learning system tools in higher education today since it provides a framework for course delivery as well as its simplicity of use by students. (Carvalho, Areal & Silva, 2011) the blackboard is characterized as a comprehensive digital platform for teaching and learning, community development, content management and sharing, and learning outcomes measurement, and is made up of interconnected modules with a core set of features that function together. It includes communication options including a bulletin board, chat room, and private e-mail. Additionally, pictures, video, and audio assets can be added to a blackboard site. Blackboard also includes instructional resources for course content, such as a lexicon, references, self-test, and quiz module. Students can also upload assignments and other resources to Blackboard for the courses in which they are enrolled. Furthermore, Blackboard provides academic staff with course administration capabilities for grading, managing student interactions, and monitoring class progress (Iskander, 2008). Such elements can ease the connection between academic professionals and students.

The purpose of this research is to employ bibliometric methodologies to examine trends in the academic literature about the use of ICT, EdTechs, and online learning in higher education. It focuses on the following research questions:

RQ1. What is the publishing and citation trend for different countries?
RQ2: Which well-known scholars have received the most attention for their publications in the fields of ICT, EdTech, and online learning in higher education?
RQ3: What is the topic's publication pattern across various countries?
RQ4. What type of relational network does the author's keywords form?
RQ5. What are the most relevant sources, including the number of documents?

3. Materials and Methods

This study provides a quantitative examination of global trends in the use of ICT in higher education teaching, drawing on previously published papers or academic publications. The Scopus database (Scopus, 2004)The papers for this study were filtered to conduct a bibliometric analysis. The study's final dataset consisted of 353 publications. These studies mostly addressed instructional pedagogy and ICT. The flowchart below depicts the paper selection procedure. The purpose of this study is to employ bibliometric methodologies to assess trends in the academic literature about the use of ICT, EdTechs, and online learning in higher education. The primary focus is on the following research questions: procedure has been explained in full below. This study presents a quantitative evaluation of worldwide trends in the role of ICT in higher education and pedagogy based on previously published articles or academic journals. Using the Scopus database, one may take a bibliometric approach that builds on previous reports and evaluations of the literature on the subject. A thorough and objective bibliometric examination demonstrates ICT training's growing relevance and validity in higher education and teaching. (Ullah *et al.*, 2023). R-studio creates graphical representations of organisational and author networks, journals, co-authorship networks, co-occurrence networks, universities, and nations. R-studio was used in this work to construct and show bibliographic data maps. Researchers (van Eck and Waltman, 2014) the most often explored types of relations include citation relations, keyword co-occurrence connections, and co-authorship ties. Citation relations are further classified as direct citation relations, co-citation relations, and bibliographic coupling relations. Weighted networks are most commonly employed for bibliometric analysis.

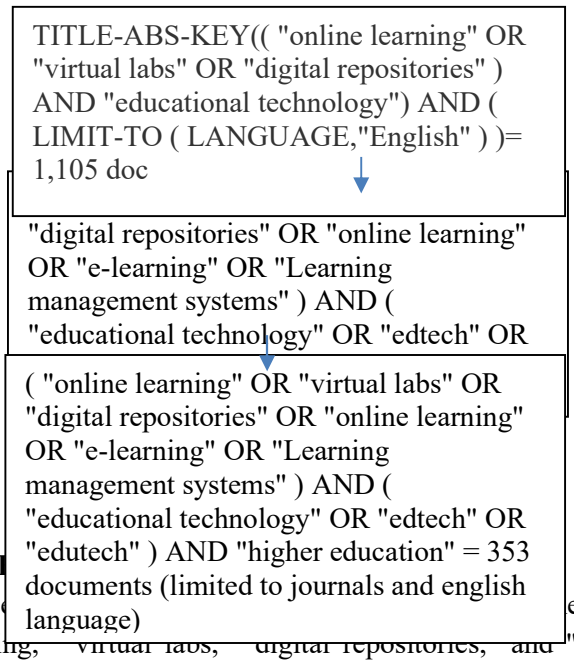

Figure 1 summarises the scre e author searched the Scopus database for terms such as "online learning," "virtual labs," "digital repositories," and "educational technologies". The findings revealed 1,105 articles. The author then included keywords such as "online learning," "e-learning," "Learning management systems," "edtech," "edutech," and "higher education," reducing the number of articles from 1,105 to 784. The author then confined the findings to journals, generating just 353 results, which comprised the study's final dataset.

4. Results and Analysis

This section focuses on the publication trends of publications in the Scopus database, as well as an analysis using R-studio. The table below summarizes the whole dataset that has been curated from the Scopus database.

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	1987:2024
Sources (Journals, Books, etc)	192
Documents	353
Annual Growth Rate %	5.4
Document Average Age	7.24
Average citations per doc	30.63
References	14653
DOCUMENT CONTENTS	
Keywords Plus (ID)	1028
Author's Keywords (DE)	989
AUTHORS	
Authors	918
Authors of single-authored docs	81
AUTHORS COLLABORATION	
Single-authored docs	82
Co-Authors per Doc	2.75
International co-authorships %	16.15
DOCUMENT TYPES	
article	319
conference paper	10
erratum	1
review	23

Table 1: Summary of a dataset through R-Studio

The data covers a significant time, between 1987 to 2024. The data is based on 192 sources, including journals, books, and other publications. The dataset contains 353 documents, demonstrating a significant amount of research effort. The document's annual growth rate is 5.4 percent, suggesting that it is expanding steadily over time, and its average age is 7.24 years, indicating that the research was just conducted. Each paper receives an average of 30.63 citations, showing its importance and impact within the academic world. The dataset comprises 14,653 references found in the literature.

4.1 Trends and Publications Related to the Countries

4.1.1 Documentation as Author's Country

The data presents and compares scientific publication output in 45 nations. The United States leads with 99 articles, followed by Australia and Spain. While the United States publishes the most high-impact articles (SCP), Singapore has the largest proportion of medium-to-high-impact publications. Interestingly, numerous nations have only published publications in low- or medium-impact journals.

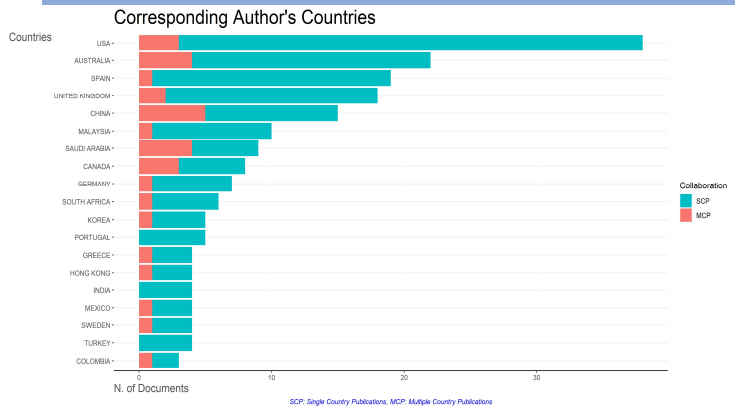

Figure 2: Documentation as Author's Country

4.1.2 Most Cited Countries

The data depicts the total count (TC) and average article citations for various nations. The United States leads with a TC of 2650 and an average citation of 69.70, trailed by Australia, the United Kingdom, and Spain. Korea comes out with a substantially higher average citation of 113.20 despite a lower TC than some other countries. The dataset shows that research production and effect vary by country, reflecting differences in scientific productivity and influence within the worldwide academic community. These measures provide insight into the global research environment, identifying nations with significant academic contributions and those with potentially burgeoning research ecosystems.

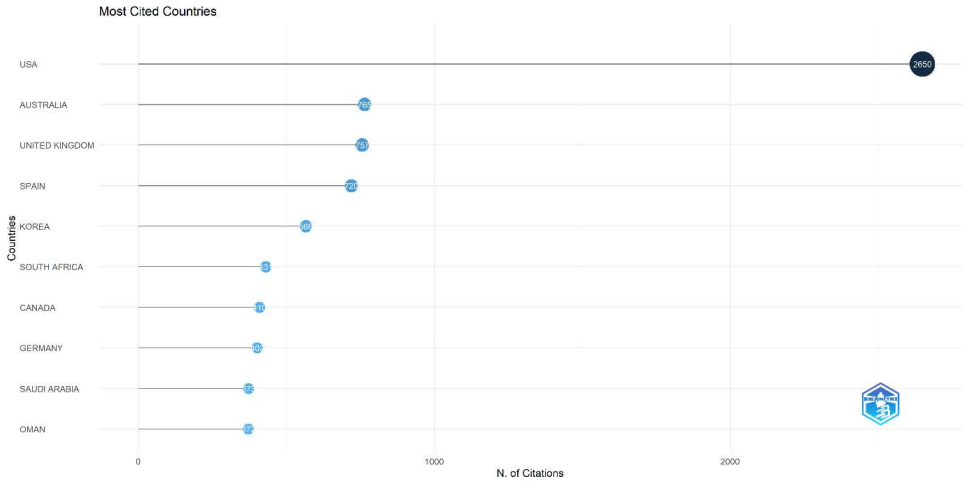

Figure 3: Most Cited Countries

4.1.3 Publication Trends of Countries

The United States has the greatest rise in publications, followed by Spain and the United Kingdom. Malaysia's expansion is more gradual. Overall, the United Kingdom and the United States published far more papers than Spain and Australia over the time. While the UK enjoyed a steady and continuous increase in publications, the USA's production began to rise more rapidly from 2010. Spain followed a similar pattern of steady expansion, although Australia's publications stayed largely constant until a significant surge in recent years.

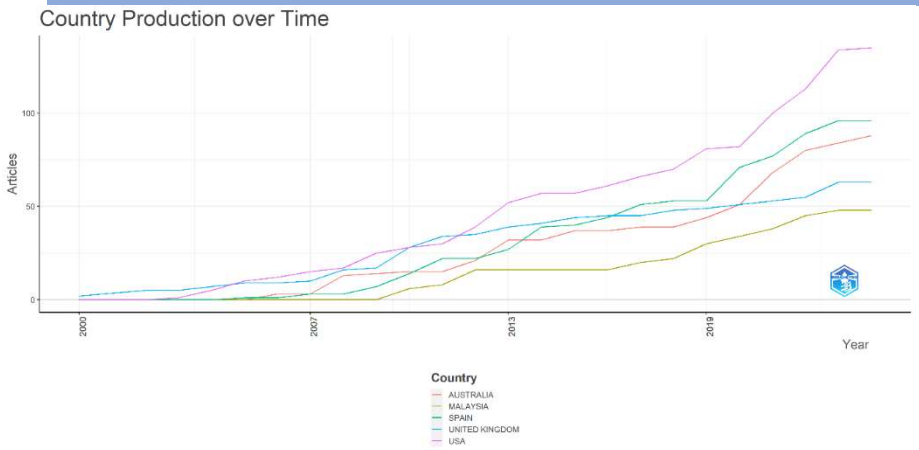

Figure 4: Publication Trends of Countries

4.2. Author's Documentation

This section discusses the most referenced papers worldwide and the most significant researchers in publications on the integration of ICT, online learning, and remote education in higher education.

4.2.1 Most Cited Documents Globally

The data offered contains information on numerous scholarly articles on the subject of educational technology and associated domains. Document by (Motiwalla, 2007) has the most total citations (663), with an average of 36.83 citations per year. The author (Tess, 2013) has 600 total citations, with an average of 50.00 citations per year, indicating its strong influence. Publication (Park and Choi, 2009) lacks a DOI yet has a substantial amount of 463 citations. The authors (Subhash and Cudney, 2018) have a high average citation per year of 55.14 despite being published lately.

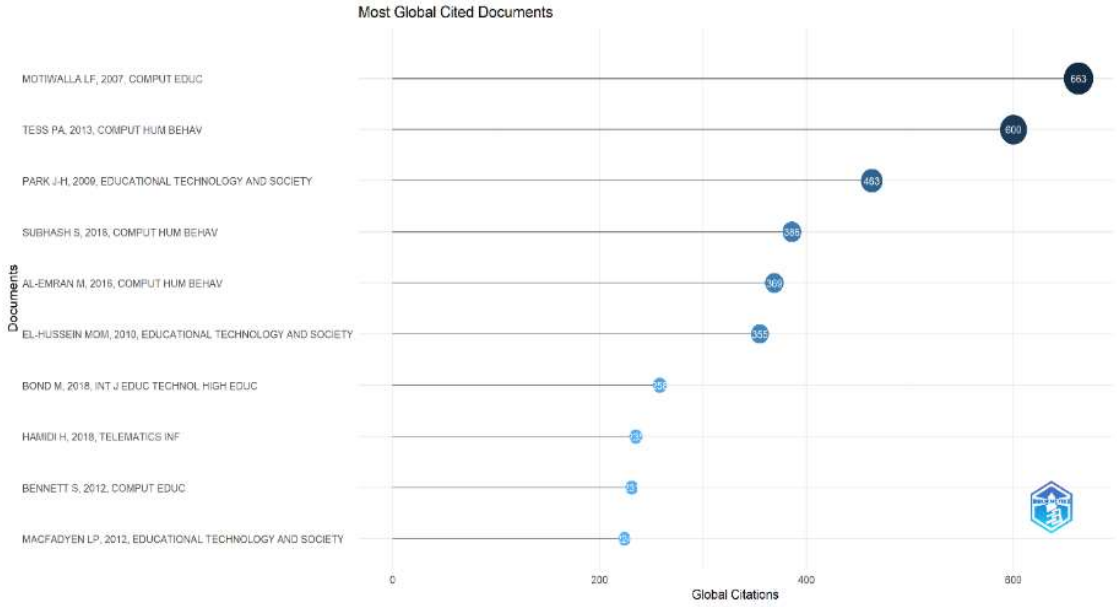

Figure 5: Most Cited Documents Globally

4.2.2 Most Relevant Authors

The data presented appears to be a summary of authors, including the number of articles to which they have contributed and the fractionalized count of their publications. This data appears to be exported data for academic publications or research output, most likely in higher education and educational technology. Each author is mentioned, along with the number of publications they have written and a fractionalized count, which might indicate their participation to collaborative articles or the weighting of their involvement in multi-author studies.

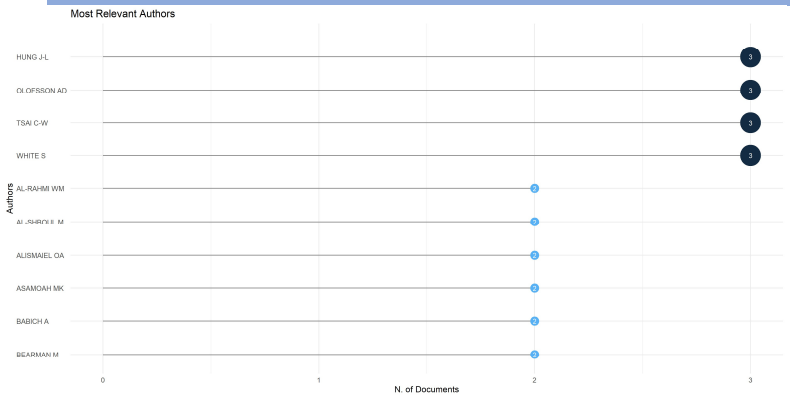

Figure 6: Most Relevant Authors

4.3 Word Cloud of Keywords

This word cloud looks to represent current trends in educational technology. The most prevalent words indicate an emphasis on Words like "online learning," "virtual reality," and "e-learning" reflect the growing use of technology for distant learning and education. The existence of "covid-19" emphasises the pandemic's significance in hastening the implementation of technology in educational settings. Terms like "students" and "surveys" imply a possible emphasis on student viewpoints and experiences using educational technology.

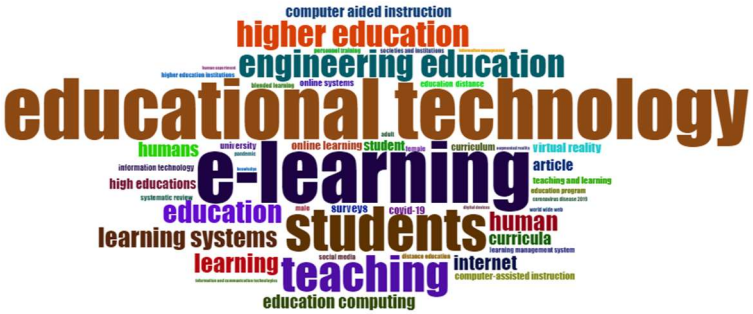

Figure 7: Word Cloud

e-learning	90
educational technology	88
students	64
teaching	53
engineering education	40
higher education	38
education	33
learning systems	29
human	28
learning	28
internet	22
humans	21
education computing	20
curricula	19
article	17
computer aided instruction	17
high educations	15

student	15
virtual reality	14
online learning	13
surveys	13
covid-19	12
computer-assisted instruction	11
curriculum	11
online systems	10
teaching and learning	10
university	10
education distance	9
information technology	9
education program	8
female	8
learning management system	8
male	8
social media	8
systematic review	8
adult	7
blended learning	7
distance education	7
higher education institutions	7
personnel training	7
societies and institutions	7
coronavirus disease 2019	6
pandemic	6
world wide web	6
augmented reality	5
digital devices	5
human experiment	5
information and communication technologies	5
information management	5
knowledge	5

Table 2: Summary of Keywords Trend

4.4 Trends and Publications Related to the Sources

4.4.1 The Most Relevant "Sources"

The exported data sheds light on the distribution of publications in major academic journals relevant to educational technology. The British Journal of Educational Technology has the most articles, with 23, followed by Educational Technology and Society, which has 16. Other prominent publications with ten articles each include the International Journal of Emerging Technologies in Learning and the Turkish Online Journal of Educational Technology. The data represents a varied variety of publications that cover many elements of educational technology, such as online learning, instructional design, and technology integration in higher education. While some publications specialise in educational technology, others, such as Computers and Education and IEEE Access, cover a broad range of issues related to

technology and education. The distribution of publications among various journals emphasizes the multidisciplinary character of educational technology research.

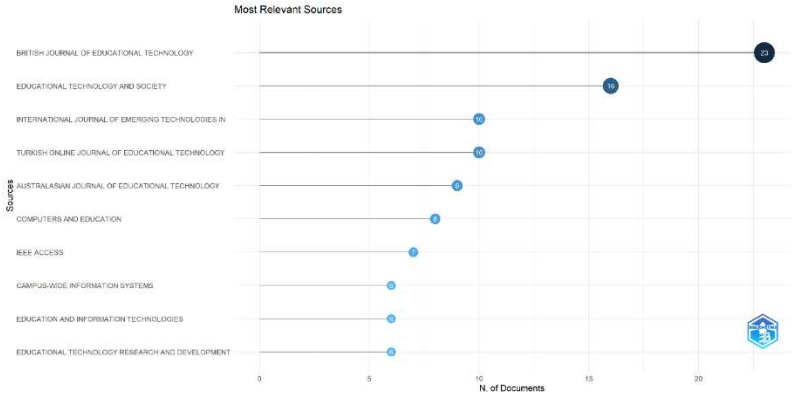

Figure 8: Most Relevant Sources

4.4.2 Sources' Production Over Time

From 1987 to 2024, the exported data provides a thorough picture of the number of papers published each year in five renowned educational technology magazines. The British Journal of Educational Technology continuously ranks first in terms of article publication, progressively growing over time and peaking at 23 articles in 2024. Similarly, the Educational Technology and Society magazine has maintained a consistent publishing pace of 16 articles per year from 1987 to 2024. The International Journal of Emerging Technologies in Learning has shown substantial development in recent years, with a large rise from two articles in 2019 to ten articles in 2024. The Turkish Online Journal of Educational Technology and the Australasian Journal of Educational Technology have similarly shown continuous rise in published

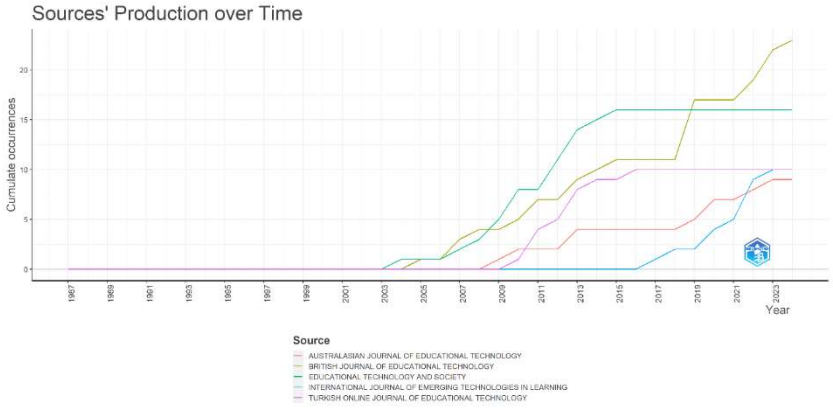

Figure 9: Sources' Production Over Time

5. Findings and Conclusion

The goal of this research is to provide a comprehensive review of research articles on the integration of ICT, online learning, and Edtechs in higher education from their conception in the literature to date. The key findings of this study revealed that the most significant authors in the field of ICT and online learning integration in teaching and learning are (Navid Shaghaghi *et al.*, 2021) and (Motiwalla, 2007), with the most papers in Scopus, USA is the most referenced nation, in comparison to other nations, India lacked the publications in Scopus, The British Journal of Educational Technology has the most articles in the field of educational technology. This study adds to the already extensive body of relevant material. It also reveals how researchers from several academic backgrounds remain fascinated by this idea. The findings contribute to the body of data demonstrating the usefulness and reliability of bibliometric methodologies for assessing the quality of ICT-related research. To particularly evaluate and validate the study's importance, longitudinal studies with instructors in a broader variety of subject areas and longer growth paths will be necessary. The

study only used the Scopus database. Other datasets may be utilized for supplementary bibliometric study. More empirical study is needed on this topic. The COVID-19 outbreak has affected e-learning patterns in higher education, as evidenced by bibliometric analysis of research trends during the outbreak. The bibliometric study reveals a dynamic landscape of research trends in the widespread use of technology for online learning. Integration of ICT, developments in e-learning systems, study of mobile learning, and acceptance of novel technologies such as eye-tracking all indicate the constant growth and adaption of educational technology in higher education. This insight may help higher education institutions make better decisions, build better curricula, and put effective educational practices into action. Continued research in this subject is critical to keeping up with technology improvements and leveraging them to improve teaching and learning experiences for both students and instructors.

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