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A Bibliometric Analysis and Future Research Agenda; ICT Implementation Challenges in Education

Hina Hashmi[1], Khurram Khan Alwi[2]
1. PhD Scholar Greenwich University, Karachi, Pakistan.
2. Professor Department of Education, Benazir Bhutto Shaheed University Lyari, Karachi, Pakistan.

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Corresponding Author:
Hina Hashmi
Email: Hina.hashmi2023@gmail.com

Abstract: *The current study is a bibliometric analysis of the literature on Challenges in ICT adoption at schools and it applies R- studio package Biblioshiny to analyse 1,381 articles from Scopus that has been published between 2000 up to April 2025. Results indicate that research in the ICT implementation area is on a growing trend and it shows an accelerating expansion from 2015 to 2017 and then there is deceleration during COVID-19 period. The developed countries: USA, UK, Spain and Malaysia have been the highest contributors and Nigeria becomes the top contributor as developing nation. This study identifies most influential universities are University of Granada, University of Hong Kong, and University Kembangan Malaysia has been dominate contributor in the field. Key journals in the field are Computers and Education, Education and Information Technologies, and Sustainability. The most citied articles are Pelgrum (2001), Ghavifekr & Rosdy (2015) and Albirini (2006). This study also highlights the prominent research trends, such as technology adoption, e-learning and mobile tools, sustainability, augmented reality and digital incompetence. Persistent issues concerning student achievement, teaching methods and school reform are still important. According to these results, ten future research questions are suggested with the aim of solving new problems and filling existing gaps in the domain through a focus on e-Learning technology, sustainability and digital divide in educational settings.*

Introduction

In recent decades, (ICT) and communication technology has transformed education significantly, altering the methods of knowledge dissemination and acquisition. At the beginning of 20th century the foundation of ICT implementation begins with the introduction of basic computer programs later on the acceleration on of mobile technologies, internet and personal computers integrated in to teaching and learning process, which results the huge and interlinked digital platforms are held in the 21st century .now the information and communication technology (ICT) has become integrated with various aspects of human life, shows a wide range of scope and extent.(ALRikabi et al., 2024) ,and special attention must be given to the application of ICTs and digital technologies in the educational and instructional process to cultivate the necessary professional competence in future professionals.(Koval-Mazyuta et

al., 2023)

Contemporary educational institutions must guide their students through a dynamic landscape of innovative digital transformation. Therefore, it can be concluded that the contemporary education system ought to serve as the leading example for the integration of the most recent information and communication technologies and digital innovations within society. The characteristics of a Smart society reflect the norms of modern culture, within which upcoming generations are born and nurtured. The education system should evolve to incorporate the features of Smart. The impact of human capital alone is insufficient for the advancement of contemporary education.(Hoel & Mason, 2018)

ICT exerts considerable effect in educational settings, significantly affecting students' learning experiences. Its extensive potential enables educators to improve instructional methods and provide comprehensive learning possibilities. Utilised as an educational instrument, ICT enables educators to improve teaching methods and offer extensive learning opportunities. This emphasizes the need of integrating ICT into education, which offers substantial benefits by preparing students with essential skills to navigate an increasingly digitised and complicated worldwide landscape.(Habimana et al., 2025)

The significance of information and communication technology (ICT) and the essential role of teachers in incorporating ICT into classroom practices have become increasingly evident in the time of the COVID-19 crisis. Technological innovation is recognized for having a significant aspect that presents greater challenges compared to other educational innovations: the essential financial investment required for its implementation.(Hassan & Geys, 2016)

Despite the importance of ICT into teaching and learning still there are challenges present in the field, although there is an elevated opinion of the availability and quality of ICT resources, the actual practice of ICT in classrooms remains at a low level, as indicated by the ICILS study. The socio-economic aspects of educational change driven by information and communication technology (ICT). They concluded that while economic costs are the initial consideration, it is essential to also address the social, human, professional, and institutional costs and involvement that follow. The presence of the Internet, hardware, and software is essential; however, it must be supported by empowered schools and educational communities. Specifically, the emphasis should no longer be on external (or first-order) barriers that may impede the use of ICT; instead, focus can be directed towards internal (or second order) barriers. The second-order barriers consist of the skills, attitudes, and knowledge associated with the integration of ICT in the classroom by those participating in this digital transformation.(Ogbu, 2025)

Problem Statement

Numerous studies individually highlighted ICT implantation challenges in education for instance lack of teacher skills and competency availability of infrastructure hinder ict implantations ,(Jahan et al., 2025a; Nyagowa et al., 2014) but a holistic understand of the study patterns, leading authors ,influential publications and emerging trends still need to be included . This gap impleads our ability to recognize research gap and new horizon of future research, which will help us to include findings in our daily classroom practices. A bibliometric analysis offers a rigorous and objective approach to fill this gap.

This study conducted a bibliometric analysis of relevant literature from the past ten years, specifically from 2016 to June 2025. This is a pioneering effort to identify the challenges of ICT implementation in the education sector through a thorough examination. The study emphasizes current evolutionary patterns by examining critical significant themes through an analysis of publication trends and identifies emerging future research agendas. Researchers can enhance the current body of knowledge by examining contemporary trends and identifying the most significant publications. Furthermore, the bibliometric analysis offers an effective strategy for deciding future research directions and assists

researchers in identifying unexplored areas or emerging trends in the 21st century that are essential for sustainable development, a significant global concern. This study conducts a thorough analysis of the literature to identify significant themes and challenges that offer guidance for research and help improved policy decisions. This study enhances the understanding of the challenges associated with the implementation of ICT in the education sector.

Research Objectives

This bibliometric analysis has following research objectives.

- To identify most influential authors, journals, publication and institutions on ICT implementation challenges in education?
- To Analyze top research trends in ICT implementation challenges in education
- Explore the future research queries on ICT implementation challenges in education

Research Questions

This bibliometric analysis has following research Questions.

- What are the most influential authors, journals, publication and institutions on ICT implementation challenges in education?
- What are the top research trends in ICT implementation challenges in education?
- What are the future research queries on ICT implementation challenges in education?

Literature Review

The education system is similar to other sectors of society, which face challenges and forced to align with the continuously growing and demanding world, however technology implementation in education plays a role of a catalyst which boost the quality of education in this rapidly growing world(Adzhemov & Denisova, 2024)

The implementation of ICT into learning and teaching process become useful in a way that it enhances the quality and speed up the curriculum coverage ,without any doubt if its goes well it will increase teachers efficacy and students' academic performance, while on the other hand if its faced challenges this will disorient teachers and students to achieve their desire goals, despite the fact that ICT plays a vital role and enhance teaching and learning experience but still educators face challenges in ICT implementation in their classrooms(Cho & Huang, 2024; Johnson & Tawfik, 2022).

Ghavifekr et.al (2017) examined the challenges faced by Malaysian mathematic teachers in their classroom, the study revealed that poor internet connectivity, limited facilities and time constrains become challenges for ICT implementation in classroom ,and there will be a need for collaboration between school leadership and education minstery for sustainable ICT implementation.

A study conducted by Mlambo et al(2020),indicates that teachers confidence and self-efficacy hinders smooth ICT implementation in their classroom practices, however if they provide continuous professional development trainings , they use ICT tools more effectively in teaching and learning process Msafari (2023) conducted a literature review on ICT integration at secondary schools and that shows, lack of access of digital tools, poor curriculum alignment, pedagogical methods and strategies, become challenging ICT implementation in educations settings.

Emmanuel (2023) explores that the first order barriers such as availability of technological resources, leadership support and teachers professional development hinder ICT implantation in learning process, similarly second order barriers includes teachers skills, teachers pedagogical belief and students familiarity with technology ,this study contradict that first order barrier are decreasing , and it emphasize the new policy ,practical implication of research .

Farhana et al (2024) indicates that teachers shows positive attitude towards the usage of ICT tools in their biology lessons, however limited access or shortage of ICT tools in educational institute, and no guidance is provided to implement ict with curriculum may hinder ICT implementation in Bangladesh biology classroom teachers, however the study suggest that if interest free loan will provided to the teachers to buy laptops and clear guidance in curriculum encourages effective ICT implantation in biology classrooms .

The most notable challenge which faced by head teachers was the availability of funds to brought or repair ICT equipment's. Although head teachers encourages teacher trainings programs ,but limited resources make hurdles ,in order to promote ict implementations effectively by head teacher, policy makers must adopt pragmatic measures to address these challenges (Lomos et al., 2024)

Jahan et al (2025b) said that poor infrastructure, unreliable internet and electricity connections and lack of teachers professional development trainings become obstacle for successful ICT integration , educational institutions needs a better infrastructure, backup electricity and internet connection and teachers professional development trainings so that they confidently used ICT in their classroom settings.

Pre-service teachers in higher education institute using ICT in their classrooms as become also a topic of interest for instance (Kadıoğlu-Akbulut et al., 2023) the study exams how ICT usage of preservice teachers TPACK technology pedagogical content knowledge using 326 participants of different universities in Turkey , the study revealed that three ICT categories , desktop software, emerging ICT tools and hardware shows one third of the variance, while the strongest overall predictor was desktop software. Lesson design and proficiency was the most contributing emerging ICT tool, whereas desktop tools were more influential in implantation, planning, and ethics, so these results suggest that different ICT tools support different areas of TPACK in preservice teachers.

In another study conducted by Suleimen, N. (2019) in higher educational institutions teachers in Kazakhstan shows that teachers generally support ICT implementation in education however lack of support, limited resources and teachers' skills become challenge for effective ICT implantation, however if teachers provided by skills, support and incentives than ICT implementation will successfully integrated in education.

The need for integrating ICT in higher education is necessary in this digital and fast growing world ,Alenezi et al (2023) highlights in his study that, the implementing ICT in higher education has three levels from low to high , in order to achieve higher level educators must need skills, confidence and support , this study also find outs the by learning in virtual reality students increases their performance and engagement. However, there is urgent need of curriculum reforms to change and adapt blended and Flipp classroom learning's.

Souheyla, (2019) underscore the importance of ICT in EFL by providing support to instructor and foster students engagement. Teacher's shows positive response in integrating ICT into teaching and learning but shows concern about inadequate trainings, traditional teaching methods and lack of awareness of importance of ICT into pedagogy. The study highlights that teachers use to adapt technology but faces challenges with their environment.

In addition to education ICT plays a vital role in other fields of life, for instance in nursing ICT play a role in communication of patients using ict tools in Peres development of explores nurses use ICT in patient communication and results emphasizes the structural trainings requirement in Order to fill the gap in academic preparation and professional development of nurses in using ICT.

Nowazie et al (2019) conduct a systematic literature review on ICT integration in nursing education in southeast Asia ,by doing thematic analysis ,they identified relevant fields using a data base like PubMed , Medlin and scopus . the review highlights the importance of ICT in teaching nursing for the future digital medical environment.

These studies illuminate understanding into various fields of ICT implantations challenges in education however in order to get in-depth knowledge in research landscape a bibliometric analysis using VOS viewer and Biblioshiny (R-language) is necessary ,by analysing the co-authorship network, co-citation ,keywords occurrence,, researcher can easily identify main authors in the field, most influential publications ,and thematic clusters with in the field of ICT implementation challenges in education, this approach gives a holistic view in research land scape , and can make a future research agenda and helpful in future policy making decisions.

The bibliometric analysis research paper on ICT implementation challenges in education is from the period of 2000 to April 2025 using Biblioshiny offers a unique approach to gain deep knowledge on ICT implementation challenges in education field. The use of Biblioshiny is a distinguish feature in this study because it provides most influential

Authors, publication journals, most citied articles and countries who contributed mainly to these fields.

Methodology

This review paper investigates the literature on ICT implementation challenges in schools using a bibliometric analysis of 1351 English language articles, which was published in between 2001 to April 2025, using Bibliometrix, R package.

A bibliometrics analysis of R package (Biblioshiny) is a comprehensive science mapping analysis of scientific production, which provide different functions, like importing of data from different sources, analysing data and visualizing a bibliographic data from various data bases.(Aria & Cuccurullo, 2017)

Research Design and Data collection

For our review paper we opt for Scopus data base because it offers extensive coverage of academic journals and maintains consistent standards for indexing. Like previous researches also use Scopus data base for bibliometric analysis (Horani et al., 2025; Narong, 2025) Scopus is one of the largest abstract and citation databases, containing a wide range of peer-reviewed articles across various disciplines. Its breadth makes it especially valuable for interdisciplinary studies or research requiring a broad view of existing literature. By providing access to numerous high-qualities, up-to-date papers, Scopus enables comprehensive and reliable literature reviews.

Bibliometrics is the collection of bibliographic data that are then analysed, in numerous ways. This approach offers a quantitative measure of the importance and impact of academic papers, covering authorship patterns, frequency of publication citation counts and keyword trends. In the present research, bibliometric metrics will contribute to evaluate the impact, authority, and degree of viability/freshness of literature on ICT implementation in schools. Search terms the search strategy is designed to retrieve academic articles about barriers and challenges schools encounter trying to implement ICT, and will use terms such as "ICT implementation," "technology in education," "school technology integration," and "ICT barriers." Or obstacles in school

The search strategy seeks to identify studies that have examined the impact of technologies (specifically ICTs) used in schools for learning purposes, with a focus upon the challenges encountered by policy makers and educationalists related to infrastructure, teacher development, policy and students' engaging with technologies. The terms will assist in narrowing the search to studies that provide information about these challenges.

Table 1: Search Criteria

Theme	Search Terms
ICT Implementation	Technology and Schools, Barriers to Education Technologies use in schools
Challenges in Education	Obstacles: ICT in education, implementation issues of technology at schools

Articles were extracted in April 2025. We only chose English publications to keep the dataset consistent and have clear analysis. A total of 20,000 articles were found using search terms as presented in Table 1. Following removal of irrelevant articles, duplicates and non-peer-reviewed sources, a final sample size of 1381 articles was identified for further analysis. These articles were selected because they are targeted to the problems of implementing ICT into schools. The emphasis on peer-reviewed papers only. The following is the inclusion and exclusion criteria for data collection for further analysis. Inclusion Criteria: Articles should be centred on ICT applications and complications in schools. Articles must be journal articles. All articles must be in the English language. Exclusion Criteria: Papers not directly associated to ICT application and educational technology. conference papers or preceding's, book chapters, or books, non-peer reviewed publications (such as editorials or opinion pieces, non-academic sources. Articles not in English.

Table 2: Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Should concentrate ICT in schools and education.	Unrelated to the use of ICT in teaching at schools
Peer-reviewed journal article,	Grey materials (editorials, opinion pieces, etc.) conference preceding's, books reviews
Must be written in English	Articles not in English

Data Analysis

Biblioshiny package of R Studio is used for the analysis. Biblioshiny is a useful website tool for the Bibliometrix package which serves to manage bibliometric data analysis and visualization. Researchers can use Biblioshiny to analyses and visualize bibliographic relations or networks, like co-authorship, citation networks, and keyword co-occurrence. It offers interactive options for users to analyse bibliometric data based on dynamic visualizations.

Analysis The analysis will be conducted in accordance with the following steps.

Descriptive Analysis: Describe the distribution of publications over years, and who are the most productive authors, journals, and countries on ICT integration research in schools.

Co-authorship networks: Visualizing complexity in the authors, institutions, and countries. This step will identify the most dominating researchers and main centers of cooperation in the area.

Keyword Co-occurrence to Identify the most used keywords in relation to schools' implementation of ICT. This will be used to identify new themes and sub-fields in research.

Citation and Co-citation Analysis: Examine how publications are interconnected in the forms of citation and co-citation. Such an analysis would be beneficial for finding landmark articles as well as highly prolific authors in the community.

The data will be analysed with the Bibliometrix functions Biblioshiny. These functions will facilitate an in-depth analysis of the bibliometric patterns in the dataset. The visualisations generated will be instrumental in the mapping of intellectual structure of ICT implementation challenges literature within schools, and offer indication into thematic progressions, as well as collaborative networks.

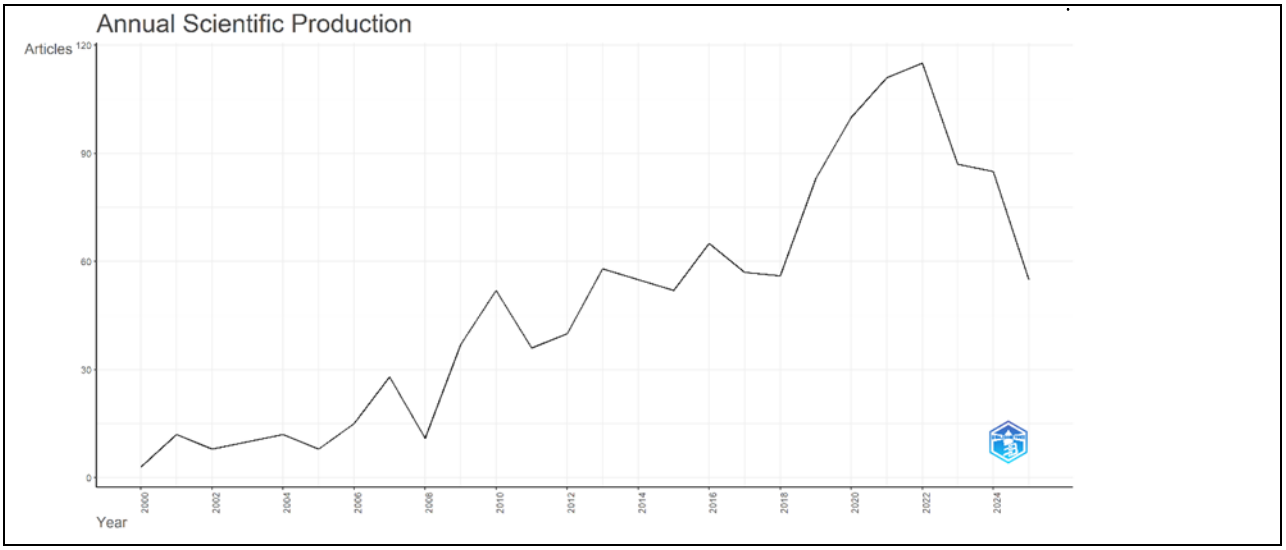
Result Description

The results will be reported in textual form as well as graphically. The results will be dynamically presented with Biblioshiny in network maps, clustering diagram, and heatmaps that illustrate relationships between authors, organizations, words, and the subject field. The most productive authors, journals and countries for the field will be gauged as well as the significant issues that are raised in research. The clustering maps will capture main themes and trends, and the citation/co-citation analysis will indicate important sources and landmark publications in ICT integration in schools.

Result

Research annual Production over the years

Fig 4.1



Source created by Author using Biblioshiny.

This figure 4.2 shows a Slow start in the early years (2000-2005) The figure illustrates the relatively low scientific output in these early years (2000-2005), with a slow increase in the number of articles published.

Increasing steeply (2006-2017): Starting in 2006, the annual volume of articles has increased sharply, culminating in a remarkably high peak in 2017. That would point to a more productive era, enabled by greater financial support, improved research infrastructure, or collaboration. Sharp rise from 2013: It looks like articles begin to rise sharply in 2013, entering a peak around 2017, and tapering downwards from there.

Immediately after the peak in 2017, the chart reveals that there is a rapid decline in scientific production, with coin lithic articles falling closer to earlier levels. Indicating a decline in research output which could be the result of many components; for example, limited funding, change of targets, or global challenges (like Covid-19) limiting the research itself.

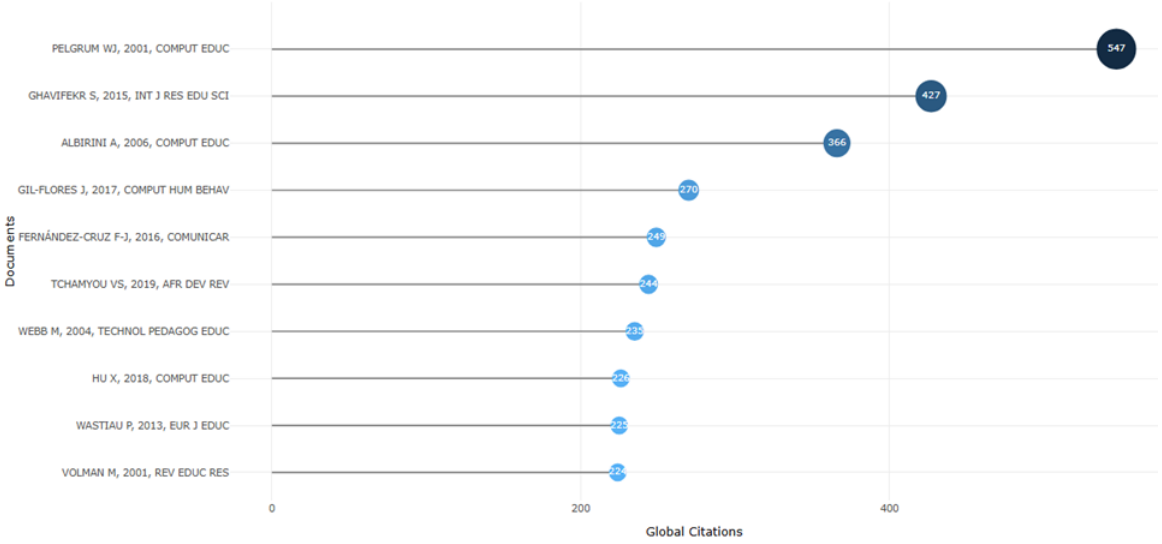
The Overall trend remains an increased number of published scientific papers since the year 2000 with a peak publication count during the 2010s, before a decrease from 2020-2024.

This trend demonstrates an overall increase in scientific productivity before a subsequent decrease or correction. And one main reason is that this data was collected in April 2025 and its one of the reasons

that the article low production in this year.

Most global cited Article

Fig 4.2



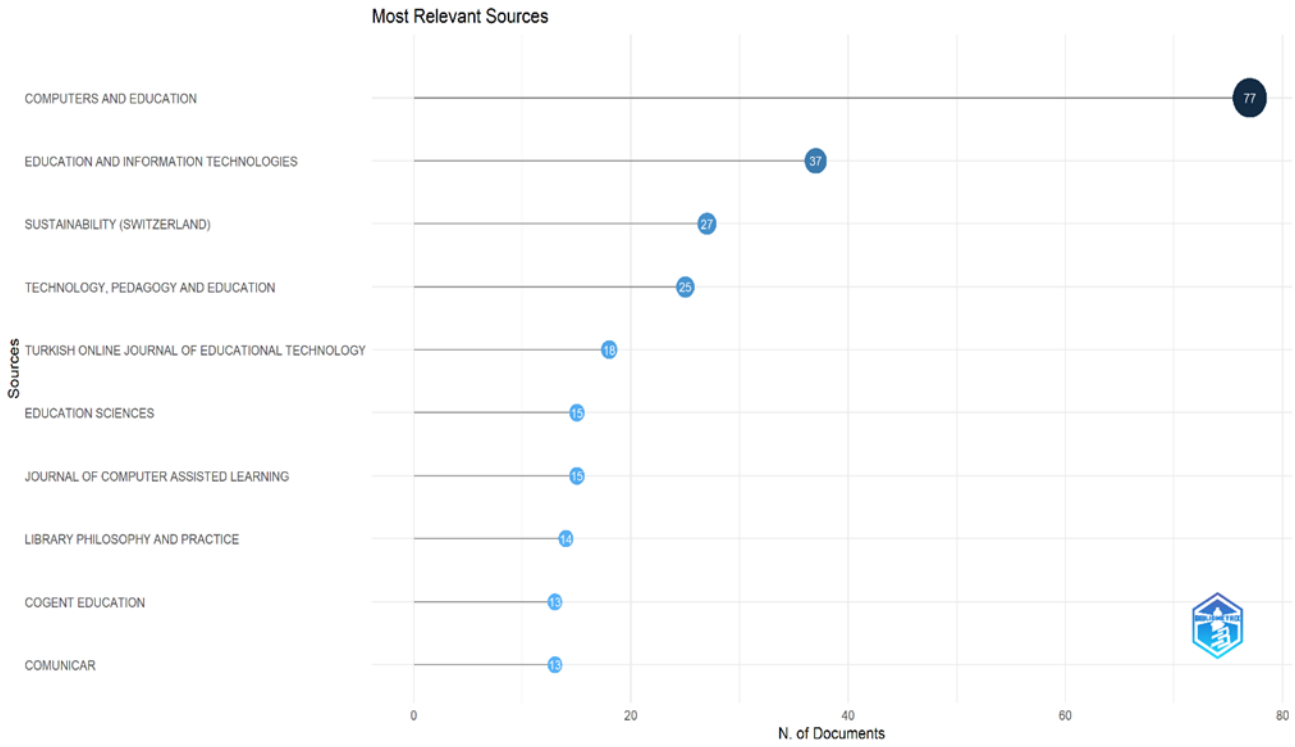
Source created by author using Biblioshiny.

The top five most cited articles in last 25 years from 2001 to 2025 which have more than 100 citations are (Pelgrum, 2001) having 547 Citations , the main findings of this paper is that the main barriers in ICT implementation include lack of teacher training, weak teacher beliefs/attitudes, insufficient technical/admin assistance, inadequate infrastructure. The main highlight of this paper is by only providing Computers is not a way to implement ICT in education.

(Ghavifekr & Rosdy, 2015) having 427 citations This paper explores ICT effectiveness, its current situation, difficulties, critics, and stances from many perspectives. Key findings of this paper are teachers view ICT integration greatly effective for both teachers and students. The main factors are availability of tools and facilities, as well as professional development. The article concludes with the recommendation to introduce more strategic planning and professional ICT management., (Albirini, 2006) having 366 citations, This paper studies the attitudes of Syrian EFL teachers towards ICT and finds predictors. The main Findings are the Competence access and competences of teachers are low. ICT is affected by computer attributes, cultural relevance, and teacher competence, suggesting the Competence and context matter along with attitude. (Gil-Flores et al., 2017) having 270 citations This paper analyses factors affecting ICT use in classrooms based on Spain Key findings of this paper are, while infrastructure is important, personal teacher characteristics, beliefs, and material use were more notable predictors. Also, a school vision and teacher teamwork study noted a factor. the last is (Fernández-Cruz & Fernández-Díaz, 2016) 249 citations. The paper focused on school priorities. This paper investigates Madrid's primary and secondary teacher digital competence with Generation Z students, the Findings suggest that Although facilities and generation are ideal for teachers to use ICT, teachers are not competent enough to develop activities.

Top relevant journals

Fig 4.3



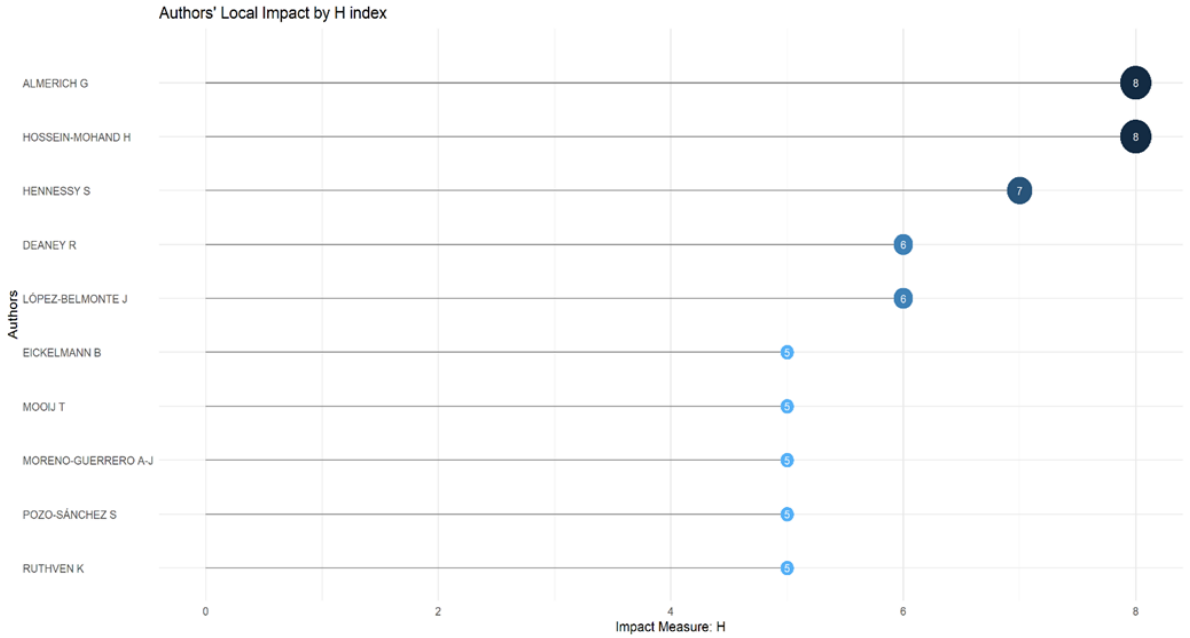
Source created by Author using Biblioshiny.

The top source is Computers and Education with seventy-seven documents, which can be considered the most relevant journal in this research domain. The second is Education and Information Technologies with thirty-seven documents, and the third is Sustainability, which has published twenty-seven documents, showing that this source is heavily focused on sustainable policies. Professional development and Technology, Pedagogy and Education take the fourth and fifth places with 25 and 24 documents published, which means that they are not as important as the top three in this list. Other sources have from 15 to 18 document, as in the case of Turkish Online Journal of Educational Technology, Education Sciences, Journal of Computer Assisted Learning, Library, and Information Science, which can also be seen as relevant to this field. Cogent Education and Comunicar can be considered as publications with a lower number of documents, which means that either they are relatively new, or their focus is more specific compared to the abovementioned options.

the Computers and Education is the flagship journal in this research domain, meaning that major works and developments can be published there. Simultaneously, it can also be considered the most competitive source that other researchers strive for. Education and Information Technologies and Sustainability are likely the most competitive options for those who are conducting research on educational technologies integrated with global sustainability topics. This diversity of journals indicates that this field is expanding and growing in terms of focus and interest.

Most influential authors

Fig.4.4

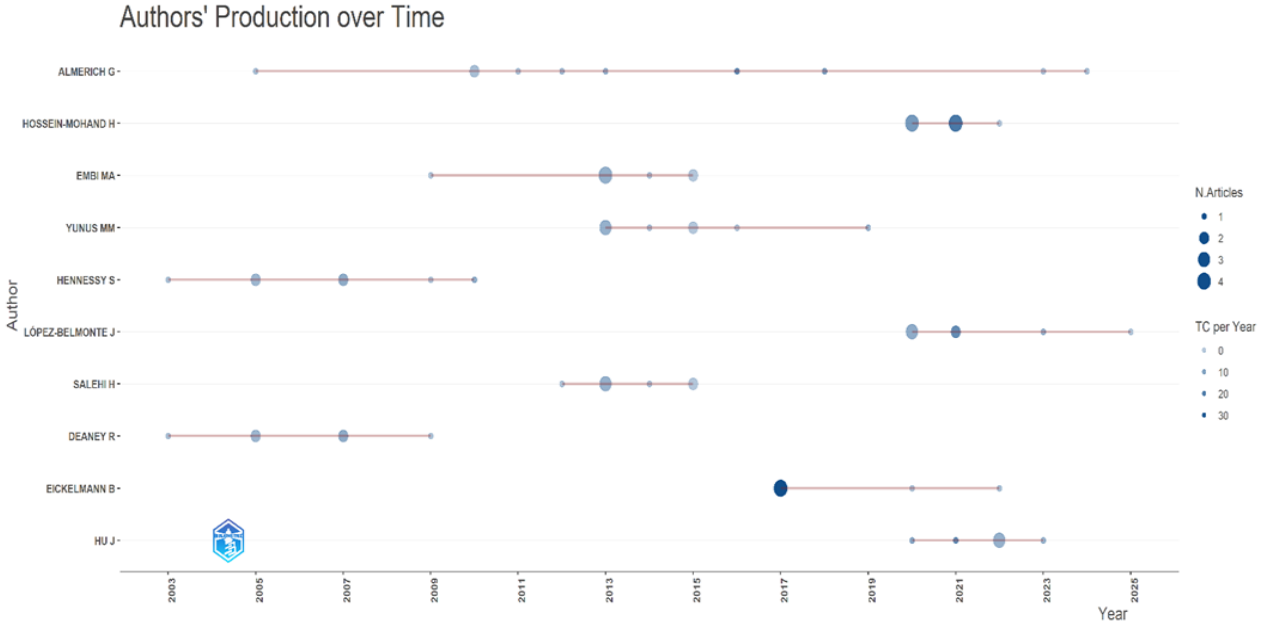


Source created By Author using Biblioshiny.

The figure 4.4 shows the local impact of the authors in the dataset, as expressed by the H-index. H-index is a metric that combines the productivity of a scientist with their publication's citation impact. The most influential authors in the dataset, Almerich G and Hossein-Mohand H, have an H-index of eight. This indicates that the authors have a substantial number of works that have been highly cited. As such, their research activity has a strong impact as at least eight of their publications have received an appreciable number of citations. The other two authors, Hennessy S and Wang WY, have H-indices of seven, which is one lesser than the top authors above. This suggests that their work compares similarly to the top authors,' but it is slightly under their impact level.

Authors production over time

Fig 4.5

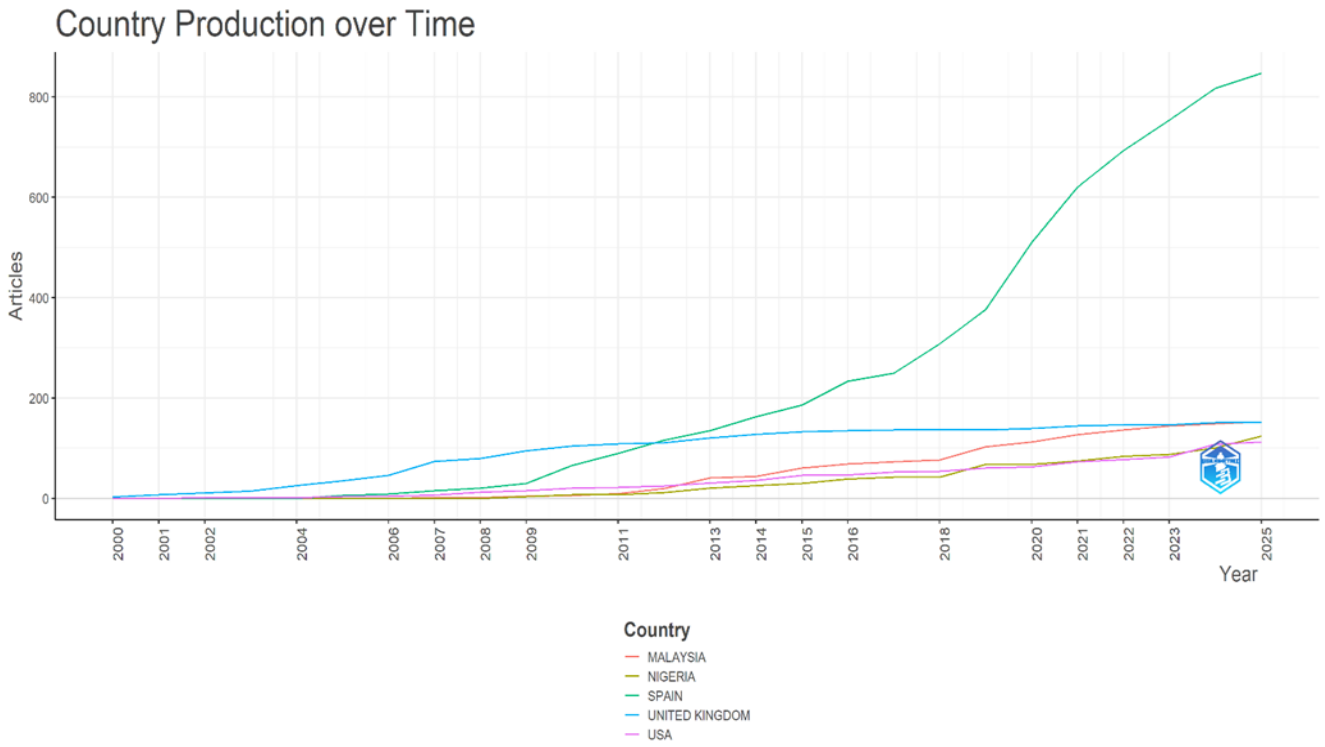


Source created by Author using Biblioshiny.

The figure 4.5 clearly illustrates the dynamics between author productivity and impact over time. The top performers with consistently high productivity and high citation activity are Almerich G and Hossein-Mohand H. T, followed by Yunus MM and Hennessy S also delivered noteworthy results, but with fewer articles and the less growing citation rate.

Countries production over time

Fig 4.6



Source created by Author using Biblioshiny.

The chart above shows the production of articles over time, disaggregated by countries. The dataset covers articles published from 2000 to 2025 all over the world the top five countries where the article is produced over time are USA, United Kingdom, Spain, Nigeria, and Malaysia.

The USA is the highest publisher of articles compared to all other countries on the list. From 2010, the increase in the USA's production rises sharply and notably constantly increases indicating a growth in research output in the USA for the past decade.

United Kingdom: The UK has consistently recorded an increase in the number of articles written with a steady rate of increase from 2010 to 2025. However, it is lower than in the USA.

Spain: Spain has had a moderate increase in article production 2010 onwards. The country's production is somewhat steady over the years. However, the increase in the number of articles is not as prominent level as in the prior mentioned countries.

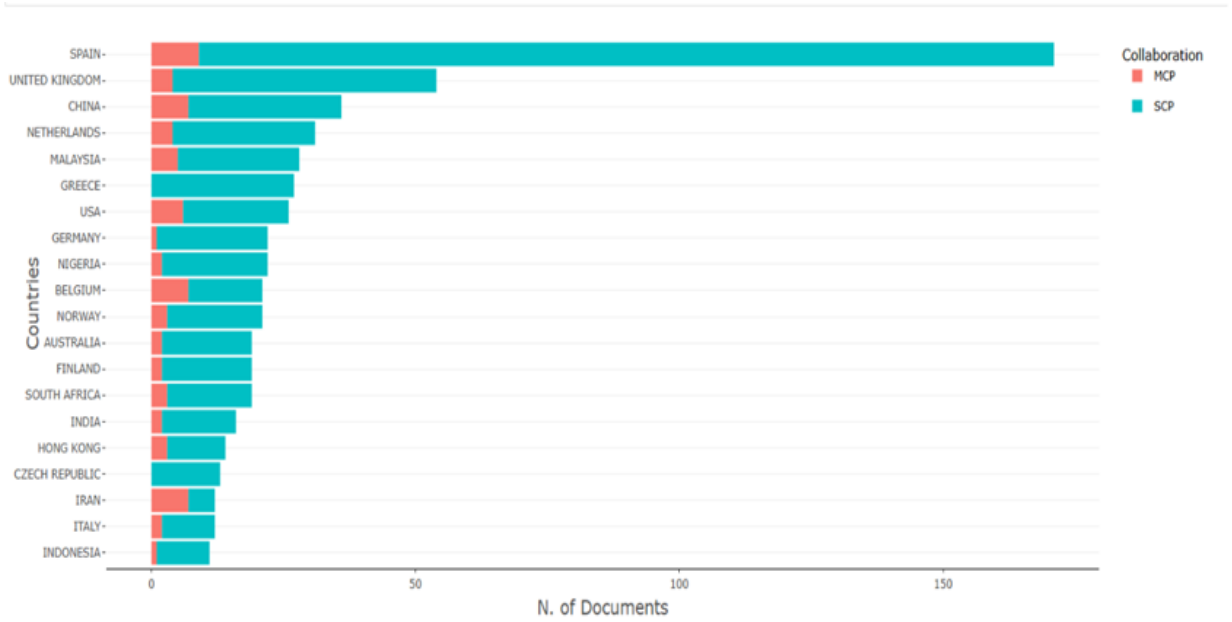
Nigeria: The number of articles posted from Nigeria was relatively low. This trend slowly increased from around 2015 compared to other mentioned countries. The article production increase is relatively consistent over time.

Malaysia: The production of articles in Malaysia has grown rapidly since 2015. The number of articles being published from 2015 seems to have increased compared to the other countries, especially from the range of 2011 and 2014.

Dominance of high-income countries. Developed countries have over the years been major contributors of articles in this field, as evidenced by the steady rate of production for the past 11 years. Growth in developing countries. The publication of articles from developing countries such as Nigeria has gradually increased from 2015. These trends reveal the changes and the rate of change in the global publication of articles. Publications from the USA and UK appear to be stable, while that for Malaysia and Nigeria is increasing permanently.

Corresponding author's countries

Figure 4.7



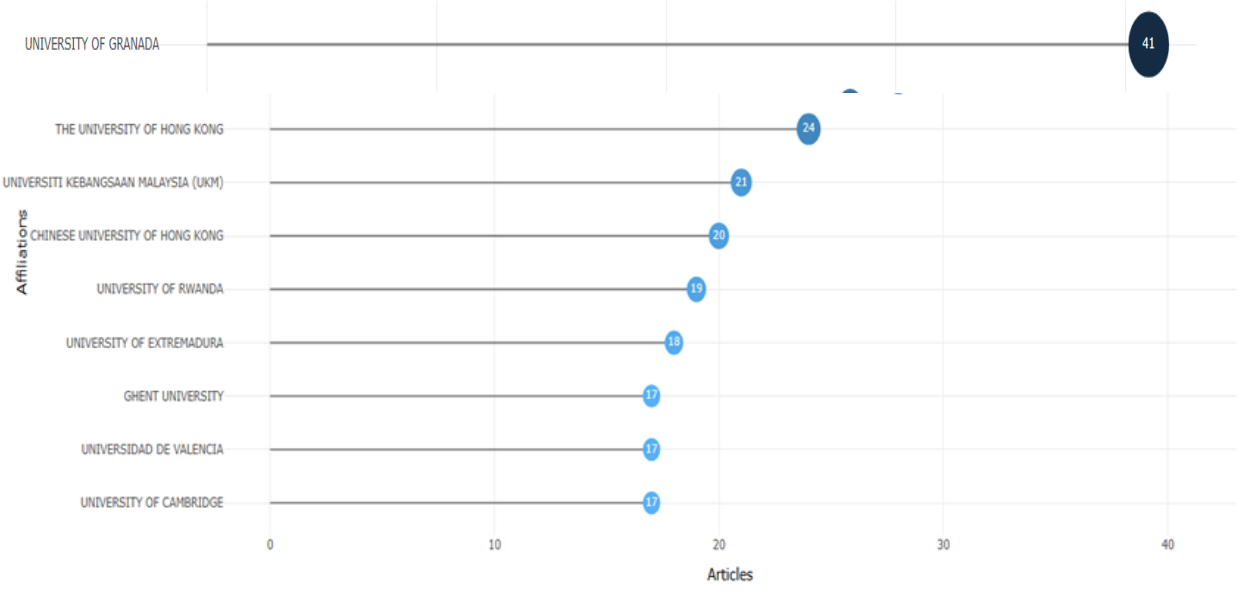
Source created by Author using Biblioshiny.

Spain is the clear outlier, contributing by far the highest number of papers. The United Kingdom sits a distant second, followed by China and the Netherlands; a mid-tier group includes Malaysia, Greece, the United States, and Germany, with the remaining countries contributing smaller but steady volumes.

Across almost all countries, single-country publications (SCP, teal) dominate over multi-country publications (MCP, red). The UK shows a relatively larger MCP share than most peers, indicating more cross-border work, while Spain's leadership is driven mainly by domestic teams. Overall, the field is organized around strong national hubs with limited international co-authorship, suggesting production is concentrated within countries rather than distributed through global networks.

Most Relevant Affiliations

Figure 4.8



Source created by Author using Biblioshiny.

the top universities by research output, as shown by number of articles representing each institute.

the University of Granada topping the list with forty-one articles, followed by other universities. University of Hong Kong comes next, having published twenty-four articles, and is trailed closely by University Kembangan Malaysia (UKM) and Chinese University of Hong Kong both with 21 and 20 articles in this regard. Some of other leading universities, such as the University of Rwanda, University of Extremadura, Ghent University, Universidad de Valencia, and the University of Cambridge had fared with between 17 to 19 each article which indicated that they have been active in research. These data show the strength of University of Granada in academic achievements and highlight the large amount of research carried out by institutions around the world, showing wide-ranging and significant forms of scholarly involvement.

countries collaborative world map

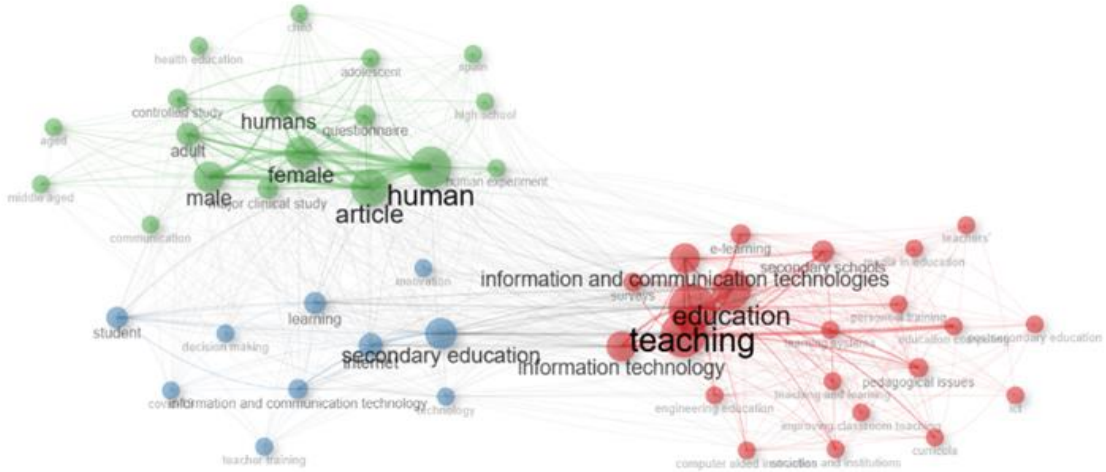
Figure 4.9

Source created by Author using Biblioshiny.

The provided map represents a world cloud of joint relations between different countries in features of ICT (Information Communication Technology) implementation aspects. The node in the centre of the is Spain (in dark blue), as it is connected with many other world regions, meaning that it is important for both exporting and importing ICT knowledge. The links stretch from Europe and Asia to Africa, and to parts of the Americas, with lines representing collaborations and common complaints. The thickness and vibrancy of the lines indicate intensity, frequency of these collaborations. The map displays a noticeable tendency for cooperation, manifesting in stronger links amongst Spain and other European countries, as well as close reinforcement from Asia and Africa, demonstrating joint efforts to overcome challenges of the implementation of ICT among various regions. These collaborations highlight the necessity of international collaboration in addressing global ICT challenges and exchanging knowledge. This network additionally reminds the importance of cross-border cooperation to surmount technological bottlenecks and implement working ICT strategies, especially in areas with nascent or formed digital infrastructures.

Co-Occurrence Network

Figure 4.10



Source created by Author using Biblioshiny.

The co-occurrence network mapping is shown relations among major terms used in human studies, education, and ICT. The map is divided into three main clusters, human, education, and information technology with rich connections between those areas.

Human Cluster (Green): The human cluster contains male, female, adult, questionnaire, and clinical studies reflecting it focus on the application of research to human subjects. This cluster focuses on the health, behaviour, and demographic characteristics, which means studies in this category are easier to be found about human experiments, gender studies, and health education.

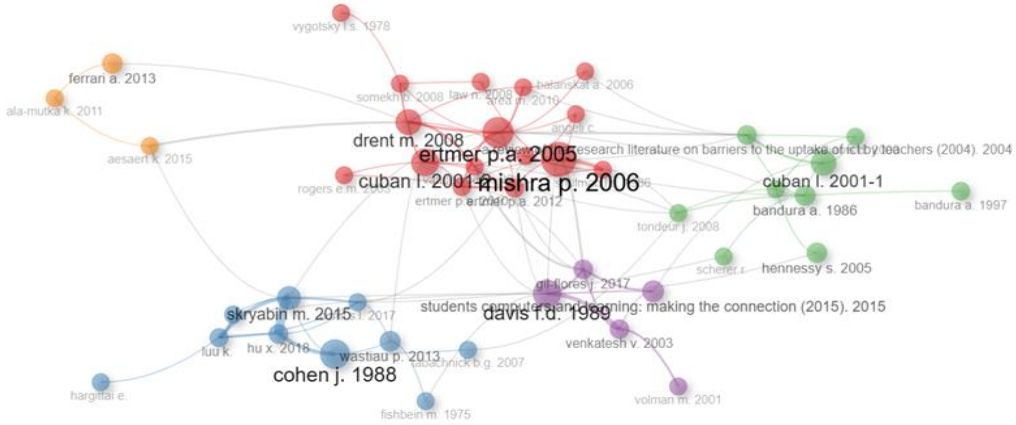
Education Cluster (Red): The education cluster is clustered with the secondary education, teaching, pedagogical issues and learning exchanging information words emphasizing Classroom Teaching. Processing and eLearning. This cluster focuses specifically on the area of integration of ICT in teaching and learning, which includes curricula and pedagogy, professional skills for teachers. That words such as computer-aided instruction and secondary schools dominate is indicative of the importance of teaching -and large-scale IT-in improving educational results.

Information Technology cluster (Blue): Tightly associated with words such as ICT, communication technology and learning technologies. This cluster focuses on the contribution of ICT to improve education and learning, indicating a growing awareness to deploy technology to support education levels, in particular secondary level education, and e-learning.

overall, the map suggests some strong relationships between human studies, teaching, and information technologies that centre on technological educational reform. The network describes how ICT is emerging as a central contributor to secondary education and the teaching profession, serving to deepen an understanding of technology's role in contemporary educational settings.

Co-citation network

Figure 4.11



Source created by Author using Biblioshiny.

The co-citation network map illustrates the relationships between different academic authors and documents in terms of ICT implementation obstacles. Nodes correspond to individual scholarly works (publication year and author name), and edges denote the frequency with which two works are cited together in the ICT-cited research domain.

Cluster 1 (Red): One of the prominent themes in this community, main topics that it explores revolve around Ertmer P. (2005), Nishra P. (2006). These works appear to be of a high impact, other frequently co-cited papers with them are Drent M. (2008) and Somekh M. (2008), indicating great contributions in the area of ICT obstacles in education delineated as well as teacher adoption. These are essential because the study is based on teacher's beliefs and technology integration' hence their findings continue to influence current research on ICT adoption Ertmer (2005) and Nishra (2006).

Cluster 2 (Blue): This cluster is related to the fundamentals in terms of ICT and education such as the foundational works like Cohen J. (1988) and Skyrabin M. (2015). These papers serve as a basis to appreciate the larger scope of ICT deployment and challenges. There is also a strong focus of this group with other highly cited works as Vygotsky L. (1978) and Hargitai E. (2009), signalling an interest in cognitive and social pillars associated to technology adoption and learning. Vygotsky (1978) and Bandura (1986) are fundamental because learning and self-efficacy respectively remain relevant in contemporary ICT adoption studies; this accounts for the sustained citation beyond 2000.

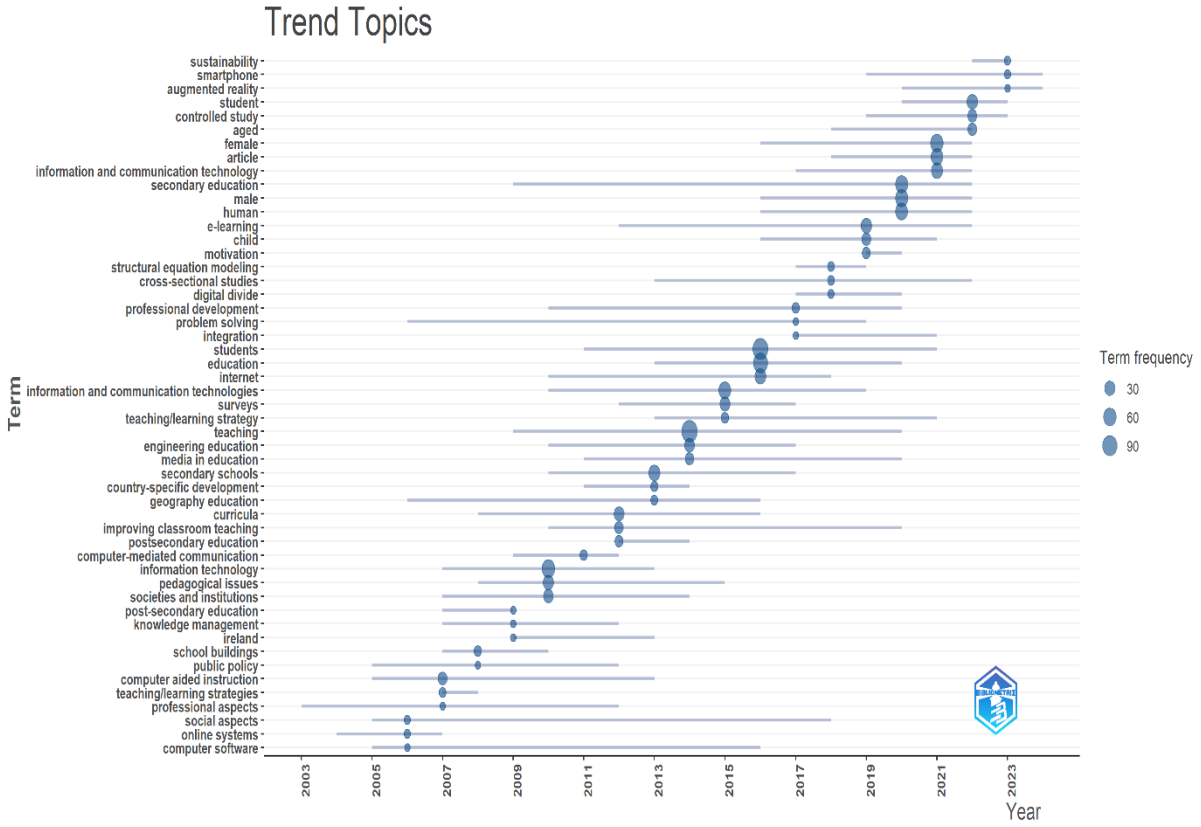
Cluster 3 (Green): The green cluster is rooted in the psychosocial considerations of ICT adoption. Works such as Bandura A. 1986 and Tondeur J. 2007 grapple with the significance of self-efficacy and social networks in ICT adoption, feeding into a wider inquiry into teacher attitudes and beliefs. Both the self-efficacy theory of Bandura (1986) and the diffusion of innovations model are influential perspectives for

understanding why teachers' confidence with ICT influences their decision making about technology adoption, which is likely one reason that Bandura's (1986) work continues to be cited regularly well beyond 2000.

Cluster 4 (Purple): Studies in this cluster focus on an investigation using organisational and policy perspective towards ICT adoption as found in works such as Gil-Flores J. (2017) and Davis F.D. (1989). These works examine the ways in which institutions and policies shape the adoption of ICT in educational contexts. However, Davis (1989) is mentioned much early due to his Technology Acceptance Model (TAM), which is still providing a model for an understanding on how teachers and students perceive and use ICT in educational contexts, making it close to the cut.

Top trending topics

Figure 4.12



Source created by Author using Biblioshiny.

Technology Adoption: Words associated with smartphones, e-learning, ICT reveal a substantial increase and therefore point to the increasing incorporation of mobile/digital tools into educational institutions.

Emerging Micro-focus Areas: Sustainability, Augmented Reality and Digital Divide are some newly arising focus areas- suggesting new challenges in world outlook such as the need to educate sustain ably and effectively, eliminating digital inequalities etc.

Long-Standing Consistent Terms: Even as there are newer terms introduced, core terms such as students, education and teaching strategies continue to be central, reinforcing that debater attention is consistently directed towards efforts in enhancing educational outcomes and processes.

Emerging Methodologies: The increase of keywords such as Structural Equation Modelling and Cross-Sectional Studies indicates a shift towards more complex research design in attempting to explore the impact of ICT in education.

In short, the study reveals how ICT in education has changed over two decades to become more mobile,

inclusive, and context-specific educational practices. It also highlights the need to recognise the benefits as well as downsides of recent technologies in wider education contexts.

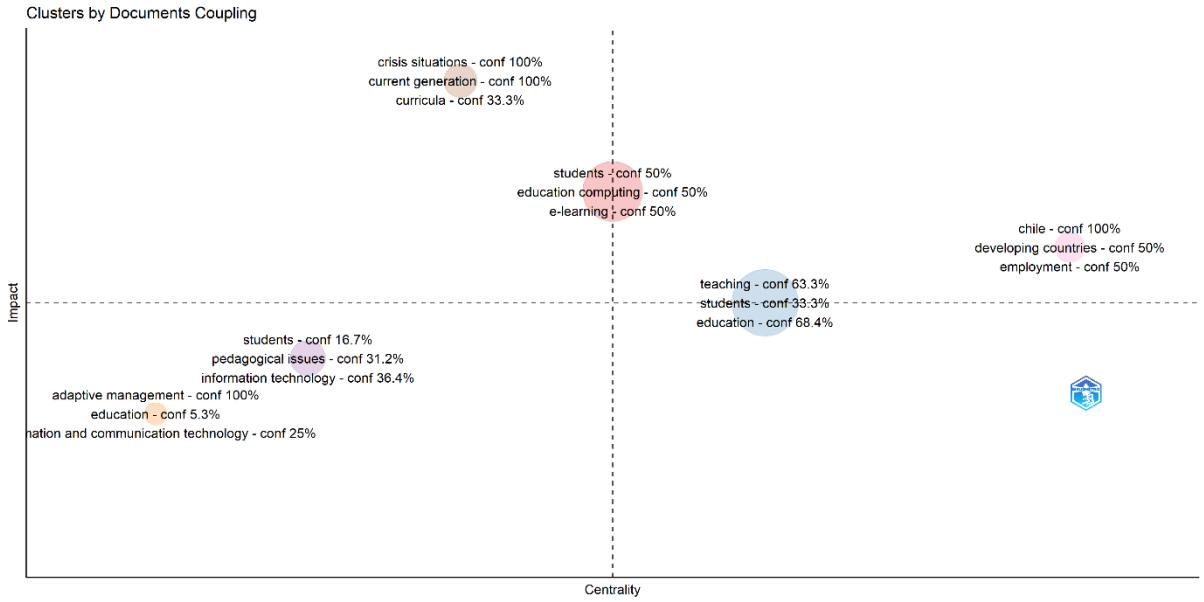
Word Cloud

Source created by Author using Biblioshiny.

The word cloud indicates that the literature on ICT integration in secondary schools mainly concentrates on students, teaching and learning process, especially e-learning and computer-assisted instructions. Key themes include the use of Information and Communication Technology (ICT) within education, most significantly, the implications for different age groups (adolescents and adults) with respect to gender differences in ICT usage. Methodologically, research is based on questionnaires and surveys to measure the utility of ICTs. The research also has pedagogical implications in terms of how it investigates the teaching form, educational institutions, and curriculum role in promoting technological innovation. Furthermore, the influence of ICT on human behaviour as well as the effect it has on educational achievements will be strongly taken in consideration.

Cluster by documents coupling.

Figure 4.14



Source created by Author using Biblioshiny.

A word cloud across quadrants is used to describe the analysis of key words.

Upper right quadrant (High Centrality, High Impact): Students, Education Computing and E-Learning: These are since they perform a systematically crucial function, as shown in the model which outlines how ICT affects Teaching, Learning and Student achievement. Chile and Developing Countries, as well as Employment, address regional challenges and opportunities for ICT uptake, particularly in developing parts of the world.

Bottom-left quadrant (low centrality, minimal impact): Education and Pedagogical Issues are less central, but they have still an issue of salience where pedagogical challenges ICT integration represents a concern but not a driving force.

Top-left quadrant (High Centrality, Low Impact): Topics such as Crisis Situations, Current Generation and Curricula are highly connected nodes that have significantly lower impact in framing the general educational practice but deal with specific contexts like disruptions (e.g., pandemics) or generational change of education.

Low Centrality/High Impact (bottom-right quadrant): Teaching Adaptive Management, these are those pedagogical adjustments and good management practices required for implementing ICT that are not likely to be highly cited but influence how systems in education evolve with recent technologies.

Overall, the research patterns give an overall picture that foundational areas (students and e-learning) are predominant in research paths, in addition to area-specific and challenging themes such as ICT in developing contexts and adaptive management, which are all necessary for depicting how ICT is updated used within education.

Discussion

This paper represents the bibliometric analysis using R studio package Biblioshiny, it's one of its own kind research projects, using research articles from 2000 to April 2025 Scopus data base, this review paper showing research trends on the topic ICT implementation challenges in schools.

The results shows the research in ICT field growing in past two decades and its being increased in 2015 to 2017, and shows a moderation in period of covid-19 (2020), and overwhelmingly and not surprisingly the developed countries contributed the most in this field the most influential countries are USA, UK , Spain and Malaysia and the most promin ate developing countries is Nigeria .

The most influential university is The University of Granada, University of Hong Kong comes next, and is followed closely by University Kembangan Malaysia (UKM) and Chinese University of Hong Kong. The other leading universities, such as the University of Rwanda, University of Extremadura, Ghent University, Universidad de Valencia, and the University of

The most influential journals which contributed in the filed are Computers and Education with 77 documents, which can be considered the most relevant journal in this research domain. The second is Education and Information Technologies with thirty-seven documents, and the third is Sustainability, which has published twenty-seven documents, showing that this source is heavily focused on sustainable policies. Professional development and Technology, Pedagogy and Education take the fourth and fifth places with 25 and 24 documents published.

The top five most cited articles in last 25 years from 2001 to 2025 which have more than 100 citations are (Pelgrum, 2001) having 547 followed by(Ghavifekr & Rosdy, 2015) having 427 citations next in the list is (Albirini, 2006) having 366 citations, than its (Gil-Flores et al., 2017) having 270 citations. the last is (Fernández-Cruz & Fernández-Díaz, 2016) 249 citations.

What researchers focuses matters in terms of research trends like Technology Adoption which

associated with smartphones, e-learning, ICT reveal a substantial increase and therefore point to the increasing incorporation of mobile/digital tools into educational institutions.

The other emerging theme is Sustainability, Augmented Reality and Digital Divide are some newly arising focus areas- suggesting new challenges in world outlook such as the need to educate sustainably and effectively, eliminating digital inequalities.

Long-Standing Consistent Terms such as students, education and teaching strategies continue to be central, reinforcing that debater attention is consistently directed towards efforts in enhancing educational outcomes and processes.

Strength and limitations

The strength of this study is that its provide an overview of latest trends in the Information communication technology filed, its gives direction for future rechallenges.lso it highlights the most influential authors, journals and countries , which is very useful for the researchers for future research in this field , however there are certain limitations in this study , the research is solely focuses on English language publish articles extracted from of Scopus data base which might missed the important works of authors in other languages and other databases the second main limitation was that it only include articles from 2000 till April 2025 which might neglect the newer researches in the filed and its also the main reason the decline in the graph in article production over time in 2025.the this limitation was that the search query like articles which use different keywords but have the same concept but due to search query there was a chance to miss those articles too, the fourth limitation was that this paper not give attention to higher education ICT implementation challenges .

Conclusion and future research agenda

The present bibliometric study aims to map the structure and dynamics of research on ICT implementation challenges in education. Output has grown, whilst influence is concentrated in only a few countries, institutes, and authors. These include themes on infrastructure shortages, teacher capabilities, curricular alignment, policy and governance deficiencies, affordability cognition; equity and inclusion awareness; data privacy issues. Methodological profiles continue to be descriptive and cross-sectional, with weak causal assessment and scant cost data. Collaboration networks are also modular and siloed regionally, limiting the propagation and transfer of knowledge to lower-resourced settings where there is greatest risk of implementation. For the field, a tension point has been reached: scale of platform deployment, AI-driven tools and their associated data ecosystems is running ahead of evidence on the effectiveness, safety, and long-term sustainability. The transition from adoption studies to implementation science is the necessary shift.

we use bibliometric citation analysis to identify the future research questions (Trinh Thi Phuong et al., 2022) using articles from 2025,2024 and 2023 for references and to extract future research questions so that the latest research questions will be emerge for further research the following table 7.0 is created

Table 7.0 future research agenda

References	Research Question
(Mohammad et al., 2025)	How can digital competency be fostered in rural areas, and how can we address the specific barriers faced?
(Acharya & Rana, 2023)	How can the shift to online learning be made more sustainable, and what can be done to address the disparities?

(Nguyen et al., 2024)	What models of in-service training best address the scalability and effectiveness of ICT skills among teachers?
(Yeleussiz & Qanay, 2025)	How can media literacy be better integrated into educational curricula to enhance digital skills?
(Griffin et al., 2025)	How can we investigate ICT skills in schools impact workforce readiness?
(Cabellos et al., 2024)	How can school facilitating conditions be enhanced to improve ICT integration?
(Yánez-Pérez et al., 2024)	To explore the effectiveness of educational apps for improving student engagement and outcomes.
(Alvarado, 2024)	What are long term effects of ICT integration on student performance in under resourced regions?
(Deriba & Sanusi, 2025)	To examine AI integration in the curriculum and its impact on learning outcomes.
(Chen et al., 2025)	what is the long-term benefits of collaborative inquiry in various academic contexts?

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