INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

ORIGINAL ARTICLE

Research Articles Published on Cloud Computing in Education as Reflected in the Web of Science - A Metric Study

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OPEN ACCESS

Received: 13/12/2025
Accepted: 08/01/2026
Published: 24/01/2025

Citation: Sasikala P, Eswaran M, Antony Raj M, Vakkil M (2026) Research Articles Published on Cloud Computing in Education as Reflected in the Web of Science - A Metric Study. Indian Journal of Science and Technology 19(3): 133-143. https://doi.org/10.17485/IJST/v19i3.1968

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Funding: None

Competing Interests: None

Published By Indian Society for Education and Environment (iSee)

ISSN
Print: 0974-6846
Electronic: 0974-5645

Abstract

Objectives: To examine worldwide trends in cloud computing research in education that are indexed in the Web of Science database between 2010 and 2024. To comprehend the evolution of this study subject, this study examines publication growth, citation impact, contributing nations and institutions, document types, research categories, and popular keywords. **Method**: The Web of Science database yielded 629 bibliographic records about cloud computing in education. Scientometric and bibliometric methods were used to analyse the data. Microsoft Excel was utilised for tabulation and graphical depiction, VOSviewer for network visualisation and keyword co-occurrence, and Bibexcel software for quantitative analysis. **Findings**: Research output increased gradually from a few publications annually before 2014 to more than 70 publications annually after 2020, with a peak in 2022, based on a study of 629 papers. Over 80% of the documents were journal articles, suggesting that peer-reviewed distribution is strongly preferred. With over 99% of publications in English, it was the most common language. Over 45% of the total output came from the top three contributors: China, the USA, and India. Major research themes reflecting both technological and pedagogical concerns were identified through keyword analysis, including education, technology adoption, user acceptance, security, and big data. **Novelty**: This study offers a comprehensive longitudinal overview of cloud computing research in education, providing academics, policymakers, and educational institutions with insights to inform future research and well-informed decision-making.

Keywords: Cloud computing; Metric; Education; Mobile Technology; Information Technology; Artificial Intelligence

1 Introduction

Scientific and technological advancements have significantly transformed education and various aspects of human life over the past two decades[(1),(2)]. Educational institutions are increasingly required to deliver high-quality instruction, effective

learning resources, and expanded academic services, often under financial constraints [3]. To address these demands, institutions have widely adopted advanced information and communication technologies (ICT), particularly computer-based and web-enabled systems, to enhance teaching, learning, and administrative efficiency [4]. Among these innovations, cloud computing has emerged as a transformative force in education [5]. Cloud computing is defined as a model that enables convenient, on-demand access to shared computing resources such as servers, storage, networks, applications, and services that can be rapidly provisioned with minimal management effort [6]. In educational contexts, cloud computing offers advantages such as reduced infrastructure costs, enhanced collaboration, flexible access to learning materials, scalable storage, and ubiquitous availability via internet connectivity [7], [8]. Despite its benefits, adopting cloud computing in education presents several challenges. Concerns related to data security and privacy, system reliability, flexibility and portability, limited internet accessibility, and customization costs remain significant barriers [9], [10]. Nevertheless, cloud computing has considerable potential to improve the management and delivery of educational services by enabling efficient content creation and dissemination and by providing students with seamless access to learning resources [11]. A metric analysis of the literature reveals several research gaps. First, empirical studies examining the long-term impact of cloud computing on learning outcomes, academic achievement, and institutional performance are limited [12]. Second, research is concentrated in technologically advanced regions, with insufficient context-specific studies from rural and low-income educational settings [13]. Third, although security and user acceptance are frequently discussed, in-depth studies on data privacy, ethics, governance, and regulatory compliance are scarce, as are comparative policy analyses. Fourth, interdisciplinary integration remains inadequate, particularly concerning pedagogical models, curriculum integration, and teacher professional development [14]. Additionally, issues of equity, accessibility, and inclusive education related to cloud computing remain underexplored. Finally, the dominance of empirical studies over systematic reviews and meta-analyses highlights the need for evidence synthesis to establish standardized frameworks for cloud computing in education [15].

In light of the foregoing discussion, there is a clear need to systematically map and critically examine the scholarly landscape of research on cloud computing in education. Accordingly, the present study examines research articles on cloud computing in educational contexts, as indexed in the Web of Science database, using a bibliometric approach. Furthermore, the analysis aims to identify underexplored areas and emerging research directions within the field. By offering a structured and comprehensive overview of the existing body of literature, this study contributes to a deeper understanding of the evolution and current state of cloud computing research in education and provides valuable insights to inform future scholarly inquiry and policy formulation in this rapidly developing domain.

In [16], the attitudes towards cloud adoption in HEIs were positively correlated with social influence, performance expectations, and enabling factors. Furthermore, the research can develop strategies for the smooth integration of learning functions using cloud technology, with significant consequences for HEIs' change management plans. In [17], it was found that cloud computing solutions enhance the sustainability and efficiency of teaching and research and development, thereby raising the standard of instruction in educational institutions [18]. The competitiveness and effectiveness of research and development, as well as instruction, are enhanced by cloud computing solutions, thereby improving educational quality. examined the cloud computing integration in the teaching-learning process [19]. The study found that principals of public secondary schools significantly differed in integrating cloud computing into their teaching and learning processes, and also explored how educational institutions used cloud computing to accelerate collaboration among schools, students, and teachers. suggested the usage of cloud computing in education. The education sector needs to develop new educational paradigms and prepare to implement cloud-based learning and teaching services. analyzed the impact of cloud computing in the education sector. analysed that e-learning has benefited greatly from technological advancements, making it more consistent, scalable, affordable, and user-friendly. The field of e-learning has been revolutionized by cloud computing, which has also greatly expanded educational prospects [20]. With these modern cloud technologies, educators can easily share course materials with students, who can receive timely notifications about exams, assignments, and other critical tasks [21]. Educators can even anticipate students' final grades and participation levels. that the possible benefits of integrating cloud machine learning and edu-cloud computing into the online learning environment [22].

Objectives of the Study

- To find out the year-wise distribution
- To find out the top 25 institutions
- To identify the language-wise distribution of records
- To determine the document-type-wise distribution of the records
- To identify the country-wise distribution of publications

2 Methodology

For this study, data sources and retrieval of 629 Cloud Computing in Education-related bibliographic documents from the Web of Science database, spanning from 2010 to 2024, were examined. Data transformation, converting bibliographic records into compatible formats for Bibexcel software, was utilised for data analysis, and VOSviewer was used to visualise the results of the bibliographic investigation. Subsequently, Analytical Tools and Techniques: Explicit explanation of the use of Bibexcel for quantitative analysis, Excel for tabulation and trend visualization, and VOSviewer for network mapping and keyword co-occurrence analysis. Bibliometric indicators: clarification of indicators used, such as publication count, citation count, H-index, country, institution productivity, and subject categories. The data were saved as text files and loaded into both Bibexcel and Microsoft Excel for careful organization, comprehensive analysis, and the production of educational tables and charts for the final report.

2.1 Data Analysis and Interpretation

Figure 2 shows the distribution of research productivity in the field of Cloud Computing in Education from 2010 to 2024. Over the past 14 years, there have been 629 research outputs on cloud computing. 2022 yielded the highest number of outputs, 143 (22.73%), while 2010 yielded the lowest number, 6 (0.95%) out of 629 records.

2.2 Year-wise Citation with H-Index

Figure 2 shows the Citation & H-Index during the study period 2010-2024 in the field of cloud computing in education; the highest h-index is 20 & citation score is 1641 in 2019. The second h-index score is 16 & the citation score in 2021 is 1040.

2.3 Language-wise distribution

Figure 3 shows the Language-wise distribution of research output. The majority of scientists prefer to publish in English. This is rated at 623. Of the total output of 629, English is the top language, accounting for 99.04%. The next Spanish language is which accounted for 4 (0.63%). The third position is held by the Portuguese, with 2 (0.31%) publications. It was observed that English seems to be the most widely spoken and preferred language worldwide.

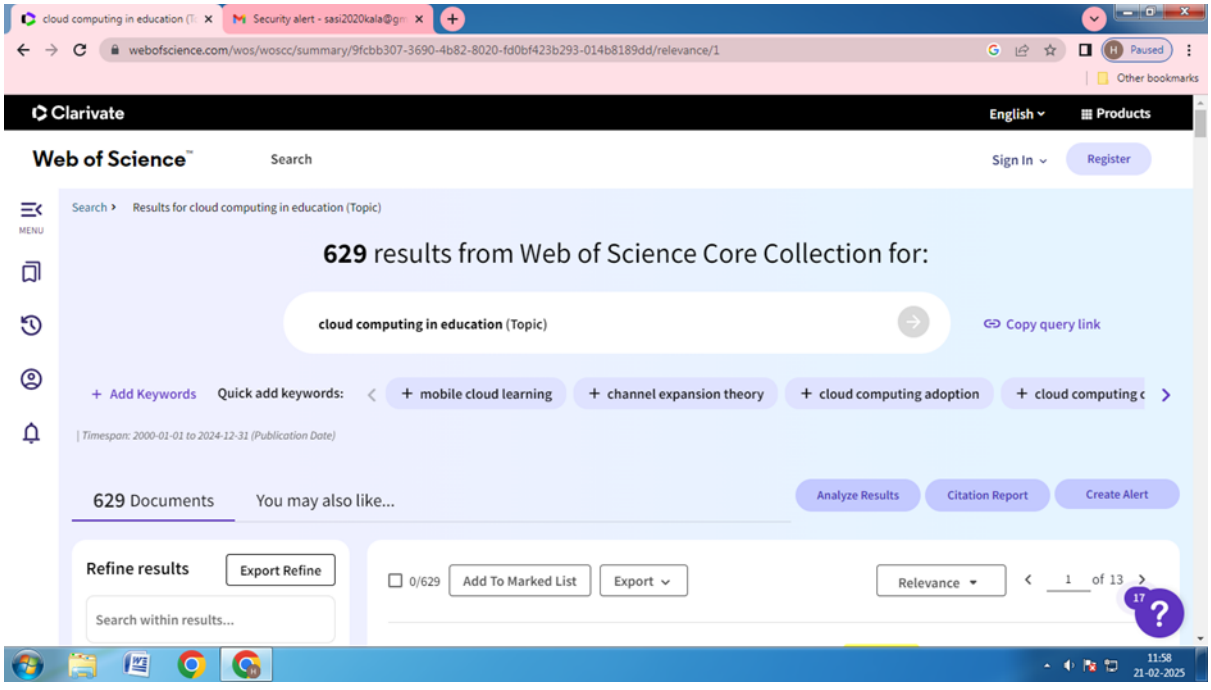

Fig 1. Evolution of scholarly output on cloud computing in education

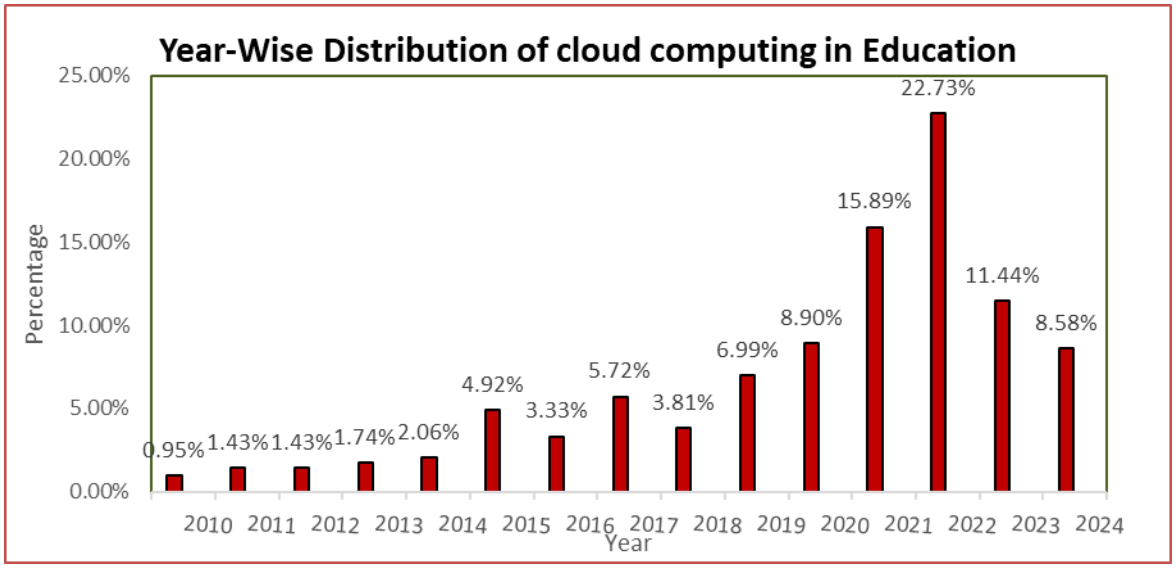

Fig 2. Year-Wise Distribution of Cloud Computing in Education Research

Fig 3. Year-wise H-Index

Table 1 identifies the top 25 countries and presents the distribution of publication output in the cloud-computing field from 2010 to 2024. A total of 629 publications were recorded during this period. The data show that China published the most research articles on cloud computing in education, with 214 papers (34.02%). The USA produced the second-highest number of papers, with 80 (12.72%), while India secured third place with 62 (9.85%).

Table 2 exhibits the document-wise distribution of cloud computing. This study identified 9 publication types in this field. The most commonly observed publication type was the article, appearing in 520 of 629 records (90.59%) in the study. The second most common publication type was the Review Article, which appeared in 44 records (7.67%). Other types of publications observed in this study included Retracted publications, Early Access Publications, proceedings papers, publications with an expression of concern, Meeting Abstracts, and Retractions.

Table 3 presents the distribution of the top 25 institutions by publication output in cloud computing in education from 2010 to 2024. The University of Malaya and Universiti Teknologi Malaysia each published the most, totalling 14 (2.44%). King Khalid University ranked second with 10 publications (1.74%), while the Chinese Academy of Sciences ranked third with 9

Table 1. Country-wise distribution (Top 25 out of 75)

Countries	Records	Percentage
Peoples R China	214	34.02
USA	93	14.78%
India	62	9.85%
Malaysia	44	6.99%
Saudi Arabia	44	6.99%
Spain	38	6.04%
Taiwan	25	3.97%
England	23	3.65%
South Korea	21	3.33%
Italy	17	2.96%
Pakistan	19	3.02%
Turkey	15	2.38%
Australia	14	2.44%
Canada	14	2.44%
U Arab Emirates	12	2.09%
South Africa	8	1.39%
France	7	1.22%
Iran	7	1.22%
Mexico	7	1.22%
Brazil	6	1.05%
Germany	6	1.05%
Ireland	6	1.05%
Morocco	6	1.05%
Norway	6	1.05%
Poland	6	1.05%

Table 2. Document type Distribution

Document Type	Record	Percentage
Article	520	90.59%
Review Article	40	7.67%
Retracted Publication	29	5.23%
Early Access	21	3.83%
Editorial Material	8	1.39%
Proceeding Paper	7	1.22%
Publication With Expression Concern	2	0.35%
Meeting Abstract	1	0.17%
Retraction	1	0.17%

publications (1.57%). These results offer insights into the institutional distribution of research output in cloud computing. Such information may assist academic institutions and funding agencies in allocating resources to organizations with demonstrated research productivity in technology.

Table 4 presents the distribution of publications across Web of Science categories related to cloud computing in education from 2010 to 2024. The Computer Science Information Systems category contributed the highest number of publications, totalling 156 (27.18%). Engineering Electrical Electronic & Telecommunication produced 114 publications (19.86%), while Computer Science Theory and Methods accounted for 58 publications (10.11%). The Education and Education Research category comprised 50 publications (8.71%), and the Business category had the lowest output, with 11 publications (1.92%). These results demonstrate the disciplinary distribution of research output in cloud computing.

Table 3. Affiliation - Wise (Top 25 Institutions out of 1049)

University/ Affiliation	Records	Percentage
Universiti Malaya	14	2.44%
Universiti Teknologi Malaysia	14	2.44%
King Khalid University	10	1.74%
Chinese Academy of Sciences	9	1.57%
King Saud University	8	1.39%
Universiti Kebangsaan Malaysia	8	1.39%
Universiti Putra Malaysia	8	1.39%
National Institute of Technology Nit System	7	1.22%
Guru Nanak Dev University	6	1.05%
King Abdulaziz University	6	1.05%
University of California System	6	1.05%
Huazhong University of Science Technology	5	0.87%
Lovely Professional University	5	0.87%
Shandong University	5	0.87%
State University of New York Suny System	5	0.87%
State University System of Florida	5	0.87%
University of Michigan	5	0.87%
University of Michigan System	5	0.87%
University of Salamanca	5	0.87%
University of Texas System	5	0.87%
Central University of Himachal Pradesh	4	0.70%
Egyptian Knowledge Bank Ekb	4	0.70%
Jazan University	4	0.70%
Prince Sattam Bin Abdulaziz University	4	0.70%
Shanghai Jiao Tong University	4	0.70%

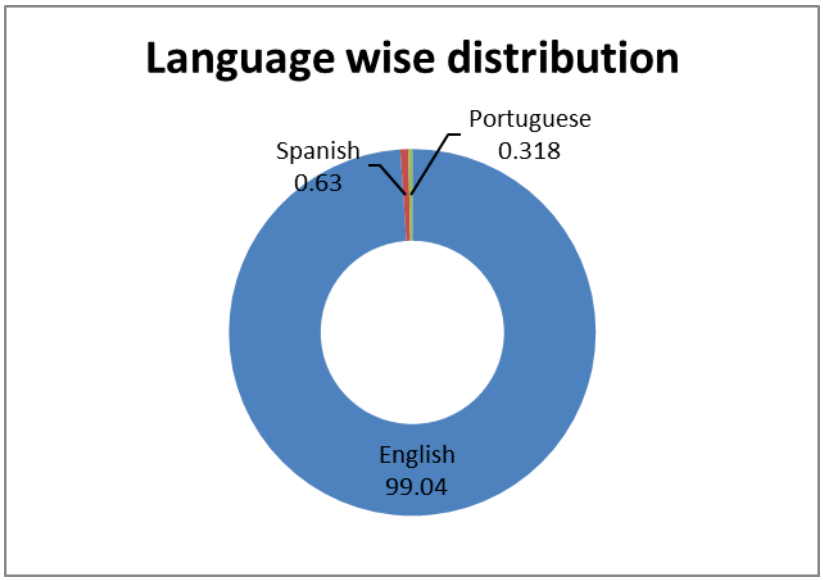

Fig 4. Language Distribution

Table 4. Web of Science categories (top 25 categories out of 98)

Web of Science Categories	Record	Percentage
Computer Science Information Systems	156	27.18%
Engineering Electrical Electronic	114	19.86%
Telecommunications	114	19.86%
Computer Science Theory Methods	58	10.11%
Computer Science Software Engineering	52	9.06%
Education Educational Research	50	8.71%
Engineering Multidisciplinary	48	8.36%
Computer Science Interdisciplinary application	46	8.01%
Computer Science Artificial Intelligence	31	5.40%
Education Scientific Disciplines	28	4.88%
Environmental Sciences	25	4.36%
Information Science Library Science	24	4.18%
Computer Science Hardware Architecture	22	3.83%
Environmental Studies	22	3.83%
Green Sustainable Science Technology	22	3.83%
Physics Applied	21	3.66%
Chemistry Multidisciplinary	18	3.14%
Materials Science Multidisciplinary	17	2.96%
Computer Science Cybernetics	15	2.61%
Mathematics Interdisciplinary Applications	15	2.61%
Management	14	2.44%
Mathematical Computational Biology	14	2.44%
Multidisciplinary Sciences	13	2.27%
Psychology Multidisciplinary	12	2.09%
Business	11	1.92%

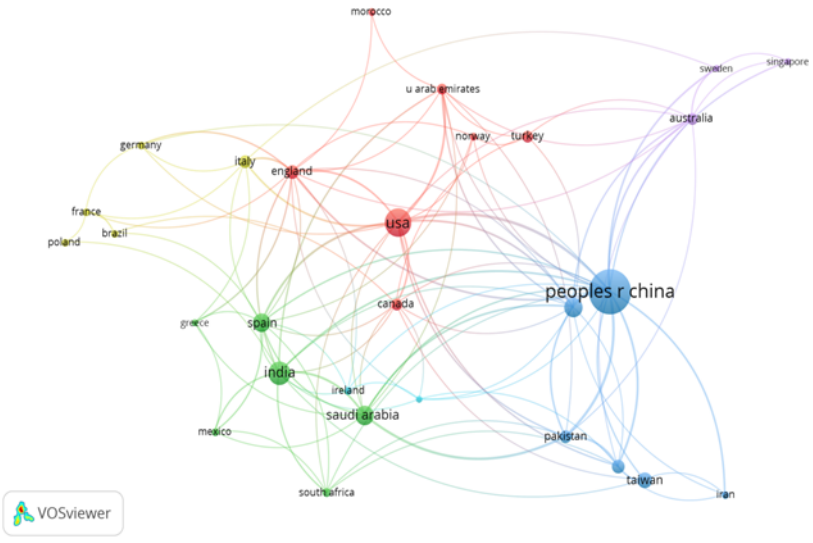

Fig 5. Country-wise

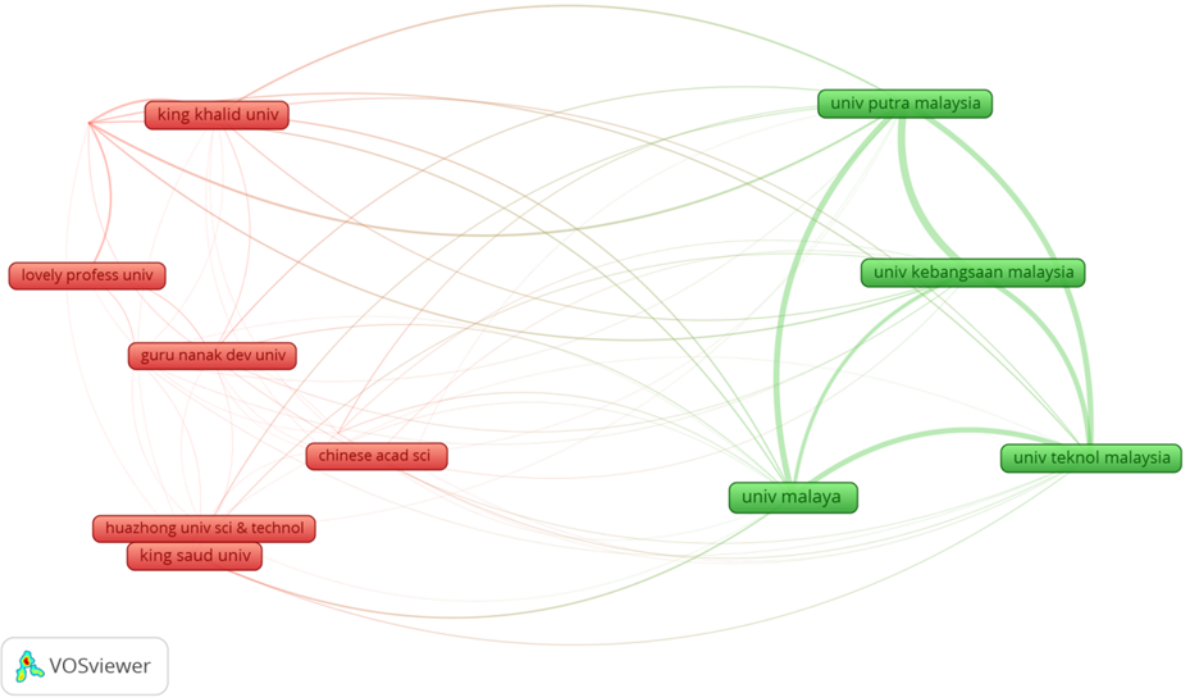

Fig 6. Institution wise analysis

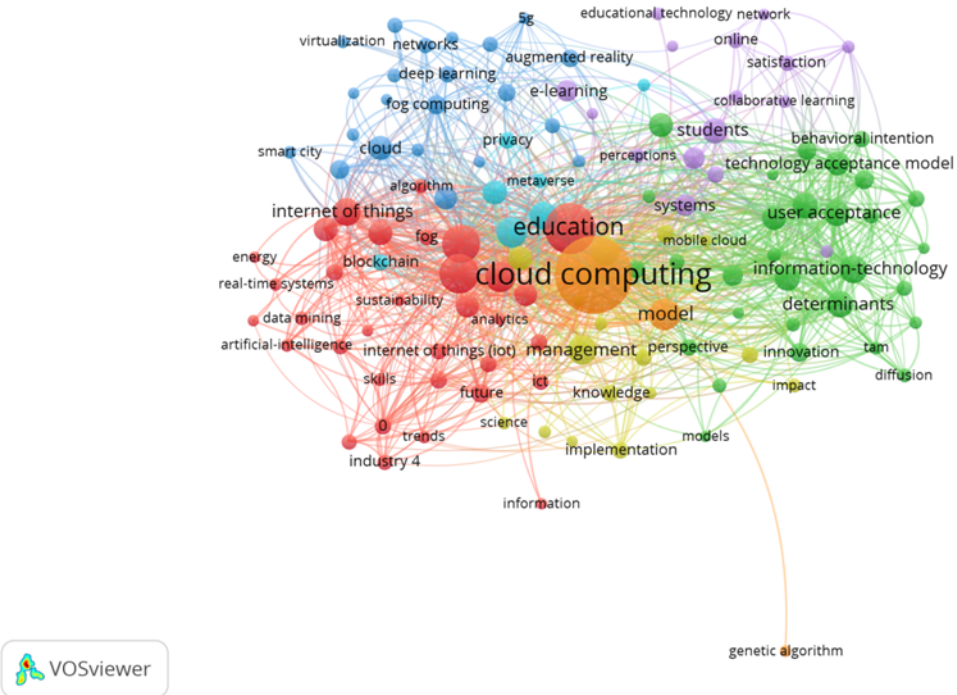

Fig 7. Keyword-wise Distribution

3 Results and Discussion

This metric study provides a comprehensive overview of research trends in cloud computing in education from 2010 to 2024, based on publications indexed in the Web of Science database. The findings clearly indicate steady, significant growth in scholarly output over the study period, reflecting the increasing relevance of cloud technologies in educational research and practice. The sharp rise in publications after 2015, with a peak in 2022, suggests that cloud computing has moved from an emerging concept to a mainstream research area, particularly accelerated by the expansion of digital learning environments and the global shift towards online and blended learning models.

The year-wise analysis reveals that although early contributions between 2010 and 2014 were limited, these foundational studies played a crucial role in shaping later research directions. The high citation counts and H-index values observed in 2019 and 2021 indicate that influential and impactful studies were produced during these years. This may be attributed to increased empirical research, adoption models, and large-scale implementations of cloud-based educational systems, which attracted greater academic attention and citations.

The distribution shows that English-language publications dominate, accounting for over 99% of the total. English is the main medium for scholarly communication in this field. As a result, research visibility and global reach depend on English-language journals. This expands international access but may limit region-specific work in other languages.

The country-wise analysis demonstrates that China, the USA, and India are the leading contributors to research on cloud computing in education. China's dominant position reflects strong governmental and institutional investment in educational technology and digital infrastructure. The substantial contributions from developing countries such as India, Malaysia, and Saudi Arabia indicate growing recognition of cloud computing as a cost-effective, scalable solution for addressing educational challenges, particularly in resource-constrained contexts. This geographical diversity underscores the global relevance of cloud-based educational solutions.

In terms of document types, journal articles constitute the vast majority of publications, underscoring the field's maturity and the preference for peer-reviewed dissemination of research findings. The presence of review articles, though limited, is significant as they consolidate existing knowledge and guide future research directions. However, the identification of retracted publications and expressions of concern highlights the need for rigorous research ethics and quality assurance in rapidly evolving technological fields.

Institution-wise distribution shows that no single institution dominates the research output, suggesting a dispersed, collaborative research landscape. Universities from Asia, particularly Malaysia and China, feature prominently, reflecting regional strengths in information technology and educational innovation. These findings may help researchers and funding agencies identify potential centers of excellence and collaboration opportunities.

The Web of Science category analysis shows that research on cloud computing in education is highly interdisciplinary, spanning computer science, engineering, telecommunications, and education. While technical domains account for a large share of publications, the presence of education-focused categories indicates an increasing shift toward pedagogical applications, learning outcomes, and instructional design. This balance between technical and educational perspectives is essential for the effective integration of cloud technologies into teaching and learning processes.

Keyword analysis further supports this observation, with frequent occurrences of terms such as "education," "technology," "adoption," "user acceptance," "security," and "big data." These keywords suggest that beyond system development, researchers are increasingly concerned with adoption challenges, user perceptions, performance, and data security. Such trends align with contemporary discussions on sustainable and ethical use of educational technologies.

The results of the current metric analysis show that research on cloud computing in education increased significantly and continuously between 2010 and 2024, peaking in 2022, and has been increasing significantly since 2015. This pattern is consistent with previous reviews and empirical research that found cloud computing to be a major factor in the scalability, accessibility, and adaptability of educational systems[(1)],[(6)]. However, the current study provides a thorough longitudinal scientometric perspective, capturing not only thematic trends but also citation impact, institutional productivity, and global collaboration patterns, in contrast to earlier research that mainly concentrated on adoption factors, system architecture, or user perceptions[(12)],[(23)]. The current study shows that the increase in research output extends beyond pandemic-driven requirements and reflects a persistent academic interest in cloud-based educational ecosystems, in contrast to adoption-focused studies conducted during the COVID-19 period[(17)]. The current study places these issues within a larger global research landscape by identifying "security," "user acceptance," and "technology adoption" as recurrent high-frequency keywords across fifteen years of publications, in contrast to studies like Almaiah et al. and Bagarish and Alharbi that highlighted challenges like security, infrastructure, and user readiness. The technological and educational advantages of cloud computing were emphasised in previous surveys and conceptual studies[(18)], but these were limited to specific areas or brief periods. On the other hand, the current study offers a multifaceted evaluation of research evolution by integrating year-wise productivity, H-index, country-

wise contributions, institutional output, and Web of Science categories in a novel way. The dominance of nations such as China, the US, and India is supported by other regional studies[19], but this study adds to the body of knowledge by using citation analysis to statistically demonstrate their ongoing leadership and influence.[24] Examines the effects of cloud-supported tools on postgraduate students' knowledge production, cognitive engagement, and collaborative learning. This empirical study[25] demonstrates the impact of cloud environments on education. The effects of cloud computing on student learning and data management explain how cloud technologies improve accessibility, teamwork, and creativity in administrative, teaching, and learning processes[26]. Demonstrates, with examples from around the world, how cloud services improve resource access, change teaching and learning, and handle security and privacy issues[27].

Overall, the discussion highlights that research on cloud computing in education has evolved from exploratory and conceptual studies to more application-oriented, data-driven, and user-centered investigations. Despite the substantial growth and diversification of research, gaps remain in areas such as long-term learning outcomes, equity and inclusion, data privacy, and policy frameworks. Addressing these gaps will be crucial for advancing both theoretical understanding and practical implementation of cloud computing in education.

3.1 Recommendations

Cloud computing platforms should be deliberately implemented by educational institutions to improve digital resource management, collaboration, and teaching and learning processes. To successfully incorporate cloud technology into pedagogy, institutions are urged to invest in secure cloud-based learning management systems and to offer faculty members ongoing professional development opportunities. Aligning cloud usage with curriculum goals and student learning outcomes should be prioritised. With a focus on data security, privacy protection, and ethical use, government and regulatory organisations should create comprehensive regulations that encourage the use of cloud computing in education. To guarantee equal access, investments in digital infrastructure and high-speed internet connectivity are crucial, particularly in rural and poor areas. Standardised and long-lasting implementation across educational sectors can be facilitated by national-level frameworks and recommendations. Future studies should examine the long-term effects of cloud computing on academic performance, institutional efficiency, and learning efficacy, rather than focusing solely on adoption and perception. To gain a deeper understanding of emerging research trends and collaboration patterns, advanced bibliometric techniques such as topic evolution, citation coupling, and co-authorship network analysis are recommended. Additionally recommended are empirical and multidisciplinary research that incorporate pedagogy, technology, and policy perspectives. The study recommends expanding bibliometric analyses to include multiple databases such as Scopus and Dimensions to enable comparative insights. Longitudinal and cross-country studies can further enhance understanding of global trends and contextual differences in cloud computing adoption in education.

4 Conclusion

This metric study offers a systematic and comprehensive overview of research on cloud computing in education published in the Web of Science database from 2010 to 2024. The findings clearly demonstrate consistent, substantial growth in scholarly output, indicating the increasing importance of cloud computing as a transformative technology in educational research and practice. The upward trend in publications, particularly after 2015, reflects the expanding adoption of digital learning environments and the growing reliance on cloud-based solutions to support teaching, learning, and institutional management.

The analysis reveals that research in this field is globally distributed, with significant contributions from both developed and developing countries. The dominance of English-language publications highlights its role as the primary medium for international scholarly communication, while the interdisciplinary nature of the research underscores the convergence of computer science, engineering, and educational research. High citation counts and H-index values in specific years indicate the presence of impactful and influential studies that have shaped subsequent research directions.

Overall, the study confirms that cloud computing has become an integral component of modern educational ecosystems, offering benefits such as scalability, accessibility, collaboration, and cost efficiency. At the same time, challenges related to security, privacy, reliability, and user acceptance underscore the need for continued critical inquiry. This study not only contributes to the existing body of knowledge by mapping research productivity and trends but also serves as a valuable reference for researchers, policymakers, and educational institutions seeking to understand the evolution and future potential of cloud computing in education. Continued, high-quality, and ethically grounded research is essential to ensure that cloud technologies are effectively and sustainably integrated into educational systems worldwide.

5 Acknowledgements

The authors declare that this study was conducted without any commercial or financial relationships that could have created a conflict of interest.

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