Contemporary Educational Technology, 2025, **17**(4), ep604
ISSN: 1309-517X (Online)

OPEN ACCESS

Review Article

Use and adoption of ICTs oriented to university student learning

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Citation: Sakhieva, R. G., Grishnova, E. E., Zhukova, M. A., Sokolova, E. G., Lapidus, N. I., & Khlusyanov, O. V. (2025). Use and adoption of ICTs oriented to university student learning. *Contemporary Educational Technology, 17*(4), ep604. https://doi.org/10.30935/cedtech/17429

ARTICLE INFO

Received: 8 Jul 2025
Accepted: 10 Nov 2025

ABSTRACT

The use of information and communication technologies (ICT) in higher education significantly improves the quality of teaching for learners. However, no bibliometric studies have analyzed the use and acceptance of ICT in higher education in the relevant literature. The aim of this paper is therefore to analyze trends and patterns related to ICT in higher education from 2005 to 2024. The data was collected from the Scopus database. The authors analyzed 4,348 articles. The results indicate that the number of publications has increased continuously from 2008 to 2024. The results also show that the journal Computers and Education published the most cited articles and that the most cited authors are from developed countries. The findings concerning most of the co-cited documents showed a wide range of methodological and theoretical approaches to ICT in higher education. Finally, the analysis of research topics over the last 20 years revealed three clusters and shows that ICT plays a crucial role in areas such as change and innovation in education, development of clinical competencies in medical education, and the rapid adoption of distance learning in the wake of the COVID-19 pandemic. These findings can guide research on technology adoption by higher education students.

Keywords: information and communication technologies, ICT, higher education, bibliometric analysis, research trends

INTRODUCTION

Information and communication technologies (ICT) is essential for teaching at universities. Higher education institutions (HEIs) have required ICT facilities to enhance student engagement, improve resource access, and prepare students for an increasingly digital world. From this perspective, ICT has numerous implications for HEIs and students (Dvoretskaya, & Uvarov, 2025; Kryukova et al., 2022; Tokareva et al., 2021). For example, computer simulations, learning management systems, and similar technologies have revolutionized teaching methods and made learning environments more adaptable and efficient for university students (Bandoh et al., 2024; Kryukova et al., 2022; Tokareva et al., 2021). These tools facilitate asynchronous learning, which improves accessibility to instruction and provides a structured framework for tracking student progress (Martín et al., 2019). The COVID-19 pandemic, which forced a rapid shift to online learning platforms, has made it even more urgent to change pedagogical approaches.

Research suggests that the use of ICT in teaching has improved student learning outcomes and expanded professional development opportunities for both students and lecturers (Agyei & Agyei, 2021). Additionally, ICT integration enables HEIs to overcome numerous systemic and logistical challenges (AbdAlgane, 2023; Jiao, & Borbievna, 2025; Korsah et al., 2024). Students from diverse backgrounds can benefit from more equitable educational opportunities when ICT effectively closes the access gaps (Seif, 2020). From this perspective, integrating ICT in higher education is crucial to ensure that educational institutions adequately prepare students for future challenges (Yushau & Nannim, 2020). It is well known that ICT refers to the technological tools and resources that facilitate teaching activities in educational institutions (Korsah, 2024), such as software (learning management systems), hardware (computers and network devices), and digital communication technologies.

After the COVID-19 pandemic, adopting innovative pedagogical approaches using ICT is necessary to optimize the effectiveness of technology in teaching and learning processes in higher education (Adtani et al., 2023). Therefore, successful technology integration through ICT is essential for improving educational outcomes and institutional operational efficiency (Jiangmei & Ghasemy, 2025). Despite the increasing research in this area, there is a notable lack of bibliometric analysis on the status of ICT in higher education. In the limited literature, no studies have analyzed the status of research on ICT in higher education. Therefore, there is a need for further bibliometric research to fully understand the development and impact of ICT in higher education and to complement and refine the existing research findings. Bibliometric analysis involves studying scientific literature and the relationships between publications on a particular research topic to examine and analyze large amounts of data in scientific research. The bibliometric method aims to identify the general characteristics of research in a specific field or topic. This form of analysis typically uses bibliographic data to assess, monitor, and understand the scientific output within a particular topic, field, or area of research. It also provides researchers with data on the patterns in research and the diversity of topics studied. Thus, bibliometric methods enable the analysis of hundreds or even thousands of studies.

From this point of view, bibliometric analysis is a powerful tool for gaining insight into the development of scientific disciplines and for addressing existing knowledge gaps and informing further researchers and studies on a topic. The present study aims to analyze trends, patterns, and critical issues related to ICT in higher education from 2005 to 2024 in the Scopus database. Specifically, this study aims to answer the following research questions:

1. What is the change in the number of publications on ICT research in higher education from 2005 to 2024?
2. Which countries and journals produced the most articles on ICT research in higher education?
3. Which authors and documents are cited most frequently?
4. What are the co-cited documents on ICT in higher education?
5. What are the most important research topics on ICT in higher education?

LITERATURE REVIEW

Adtani et al. (2023) examined the status of ICT in academia. They used the Scopus and Web of Science databases for data collection and the VOSviewer software for analysis and to understand the extent to which

faculty members in some well-known higher educational institutions are adopting new pedagogical approaches. Their findings showed that significant digital transformation occurs in the teaching and learning process during the COVID-19 pandemic. They also found that the common theme was challenges, the impact of ICT, and techniques for introducing ICT alongside mobile learning and social media. Miranda and Tolentino (2023) employed bibliometric analysis to describe the use of ICT in health education. Their results suggest that research in ICT for health education has remained relatively stagnant. Most published health technology research focused on nursing, e-learning, social media, higher education, communication, and distance education. Western countries dominated the number of publications, and the USA remains the most productive country in this area of research.

González-Zamar et al. (2020) examined research in the period 2000-2019 on the management of ICT for sustainable education in higher education. They used the Scopus database. Their results indicated an exponential trend, particularly over the last five years. They concluded that there is a growing publication trend at the international level, which makes it possible to determine the relevance of research on ICT management for sustainable education in the context of higher education. Jiangmei and Ghasemy (2025) examined the status of the ICT competency framework for higher education teachers using bibliometric methods in Scopus-indexed publications from 2008 to 2024. Their findings showed that the instructors' ICT competency framework offers greater flexibility and allows other HEIs to contextualize these standards for developing teachers' ICT competence based on their specific needs. Furthermore, their analysis revealed an increasing trend in research on teachers' ICT literacy. Moreover, they noted the thematic development of keywords and research topics involving ICT literacy and distance education.

Martin et al. (2019) identified meta-trends in technology based on the perceptions of engineering education researchers and practitioners. Their findings demonstrated the predicted impact of ICT technologies, including MOOCs, e-books, digital libraries, and e-learning platforms, on engineering education. Contreras et al. (2022) analyzed the scientific production of ICT and learning and knowledge technologies (LKT) to improve pedagogical innovation and/or teaching/learning processes in distance and/or virtual higher education. They analyzed about 11 bibliometric indicators. Their results indicate that the term LKT is not widely used in academic databases, and that most publications focus on ICT. They found that research trends in ICT topics focus on e-learning, b-learning, the use of MOOCs to mediate education, the use of social networks for educational purposes, the enhancement of students' and teachers' digital competences, the promotion of pedagogical innovation through technology, evaluation through technology, the use of mobile devices such as tablets or cell phones in the use of ICT in higher education, collaborative learning and the use of virtual learning environments. They also found that Spain is among the countries with the highest number of publications. In contrast, Latin American countries such as Colombia and Argentina show growth in the number of publications on this topic.

These studies offer a comprehensive perspective on the role, impact, and utilization of ICT in higher education. In summary, the findings of these studies show that the pandemic has accelerated the digital transformation in teaching and learning processes and the widespread adoption of ICT (Adtani et al., 2023). Researchers have seen ICT not only as a technological tool but also as a tool for pedagogical innovation and sustainability. In this context, studies examine the impact of ICT applications such as e-learning, mobile learning, social media, MOOCs, and digital libraries in education. Most studies (e.g., Contreras et al., 2022; González-Zamar et al., 2020; Jiangmei & Ghasemy, 2025; Miranda & Tolentino, 2023) used bibliometric analysis methods to investigate the status of ICT in education. However, the results and scope of these studies are minimal. In summary, these studies offer valuable insights into the current status and future directions of ICT in higher education. However, no comprehensive study in the current literature analyzes the studies on ICT in higher education. For this reason, it is important to promote interdisciplinary approaches to understand the impact of ICT in education.

METHOD

We conducted a bibliometric analysis to identify the most influential, impactful, and prominent documents, sources, and authors. This analytical approach allows us to explore emerging research trends and investigate topics on ICT in higher education. The first step in answering the research question was to

Table 1. Data search criteria

Criteria	Description
Source database	Scopus
Inclusion criteria	Articles in peer-reviewed journals, published in English language
Exclusion criteria	Reviews, editorials, notes, conference papers, letters
Years	2005-2024
Keywords used in the search	Information communication and technologies, digital technologies, technology-enhanced learning, ICT in education, ICT, computing technologies, information technology, communication technology, e-learning, mobile learning, web-based learning, learning, management systems, interactive technologies, virtual learning environments, artificial intelligence in education, ICT literacy, technology integration in education, tertiary education, post-secondary education, higher education, university education, higher learning, undergraduate education, and graduate students
Search place	Keywords
Subject areas	Social sciences
Documents total	4,348 articles

collect the data. We used the Scopus database for data collection. We used several keywords to collect data relevant to ICT in higher education. We searched the database in advanced query mode, focusing on the title, keywords, and abstract fields. We also used the Boolean operators "OR" and "AND", specifically "information and communication technologies" and "higher education". Using these keywords, the database search yielded 1,846 documents. We completed the search in April 2025.

The second step was to screen the data using inclusion and exclusion criteria. We identified 4966 articles published in peer-reviewed journals. We excluded books, conference proceedings, and other publication formats such as editorials and notes based on our criteria. Therefore, we limited our search to publications published in peer-reviewed journals. In the search, we restricted the filter option to limit publications and selected articles published between 2005 and 2024. We only considered articles published in the English language. This screening process ultimately yielded 4348 documents for further analysis.

The third step was data analysis and visualization. We downloaded the metadata for the 4,348 articles published in the database and exported all the information in the metadata file in CSV format. The metadata included all information such as title, publication year, journal, number of citations, author names, affiliations, countries, author keywords, funding sources, and cited references. We used the metadata for analysis in the VOSviewer software. Our study focused on the authors and keywords with the highest citation counts to create network maps, as indicated in the metadata. **Table 1** shows the inclusion and exclusion criteria applied in this study. During the analysis, we attempted to derive trends in the growth of the research field by examining the annual number of publications. To this end, we also identified the 20 most-cited authors and the 20 most prolific journals.

We also analyzed the ten most-cited articles. For these analyses, the VOSviewer software enabled the visualization of network maps of co-authorship between countries and co-occurrence networks of keywords. The results of these visualizations provide valuable insights into the interactions between the analyzed variables, shed light on the intellectual structure of the research topic, and highlight important research topics relevant to ICT in higher education.

The fourth and final step was interpreting the data. All researchers contributed to this process, which examined research trends, countries, and journals, the most frequently cited authors and sources, co-authorship networks, and prominent research topics and trends in detail.

RESULTS

Change in the Number of Publications

The growth of publications on ICT shows a general trend of increase. **Figure 1** shows the annual growth of publications in the field of ICT in higher education. Initially, in 2004, only 35 publications were recorded. This number rose steadily in the following years, with 36 publications in 2005 and an increase to 106 in 2008. The number of publications continued to rise until 2012. One hundred and sixty-four articles were published in 2012. In 2013 and 2014, however, the annual number decreased, and the number of publications fell. After 2014, the number of articles increased again until 2019. After 2019, there was a significant increase in

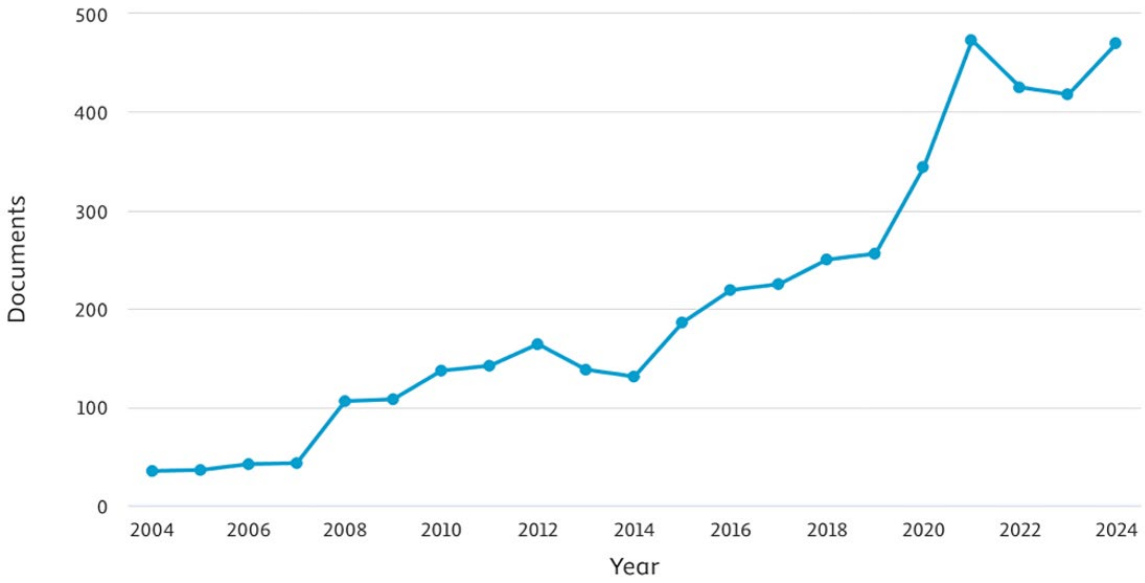

Figure 1. Annual growth of ICT publications in higher education (Source: The authors' data)

publications until 2024. Growth is strongest between 2019 and 2021. Four hundred seventy-three articles were published in 2012. The number of publications fell slightly in 2022 and 2023. In 2024, 470 articles were published.

Countries and Journals With the Most Publications

According to Scopus, 171 countries engaged in research in ICT publications. We chose the first twenty countries identified as making substantial contributions to this field. The USA ranks highest, with 814 publications, 25,918 citations, and a link strength of 2,992. These results show that the USA is the clear leader. Not only is it the most significant contributor with 814 documents, but it also tops in total citations and link strength. This indicates that the USA is very productive in ICT in higher education. Spain, with 430 documents, and the UK, with 408, stand out as Europe's leading countries in this field, ranking second and third, respectively. Australia and China occupy the third and fourth positions, with 279 and 225 publications, respectively.

Asian countries such as China, Malaysia, and India stand out with their number of documents and total citations. Malaysia, in particular, holds a significant position in total link strength. Conversely, Taiwan is notable for its high number of citations despite producing few documents. Regarding total link strength, countries such as the USA, the UK, and Australia are highly influential in international cooperation.

A regional analysis reveals that the USA is the leader, surpassing other countries regarding the number of documents and citations. Canada, despite producing fewer documents (133), is an influential actor in terms of link strength and number of citations. These results show that North America is the global leader in ICT and a leading region in terms of both productivity and influence.

Regarding Europe, Spain, and the UK are Europe's leading countries in ICT. Spain's total link strength (1,963) and number of documents are quite remarkable. Germany, despite producing fewer documents, has a significant academic impact, characterized by high citation and link strength. The Netherlands and Portugal, despite being smaller countries, are notable for effective collaborations and scholarly contributions. In addition, results also revealed that Italy and Russia contributed less than other European countries.

Concerning the Asia continent, our results demonstrated that China stands out as the leader in Asia. The number of documents and citation rates are much higher than in other countries in the region. The results also demonstrated that Malaysia and India stand out with high document counts and citation rates. Malaysia's link strength (151) is also relatively high. In addition, Saudi Arabia is regarded as a significant player in Asia. It follows Malaysia and India in terms of the number of documents. Taiwan and Hong Kong are notable for their high number of citations despite producing relatively few documents. This finding shows the quality and impact of their publications.

Table 2. Twenty countries contributed most to ICT in higher education

Rank	Country	Documents	Total citations	Total link strength
1	USA	814	25,918	299
2	Spain	430	13,846	196
3	UK	408	14,413	273
4	Australia	279	11,835	215
5	China	225	4,935	130
6	Malaysia	179	5,402	151
7	Canada	133	4,415	128
8	Saudi Arabia	129	4,788	120
9	South Africa	123	2,724	92
10	India	121	2,154	113
11	Germany	114	3,499	123
12	Taiwan	112	5,942	44
13	Russia	102	1,234	59
14	Turkey	94	2,266	87
15	Mexico	86	1,072	89
16	Indonesia	83	1,458	65
17	Netherlands	75	2,554	82
18	Portugal	70	2,388	58
19	Hong Kong	66	2,442	77
20	Italy	61	2,024	87

Table 3. Twenty countries contributed most to ICT in higher education

Rank	Journals	Documents	Total citations	TLS	Q
1	Computers and Education	276	33,369	641	Q1
2	International Journal of Emerging Technologies In Learning	231	4,419	89	NA
3	Sustainability Switzerland	200	6,647	149	Q1
4	British Journal of Educational Technology	131	7,181	234	Q1
5	Education and Information Technologies	112	3,395	179	Q1
6	BMC Medical Education	107	2,080	21	Q1
7	Internet and Higher Education	90	9,511	200	Q1
8	International Journal of Engineering Education	85	651	20	Q3
9	Journal of Surgical Education	81	1,319	2	Q1
10	Journal of Chemical Education	76	1,712	9	Q2
11	Cogent Education	73	268	41	Q2
12	Computer Applications In Engineering Education	65	1,176	28	Q1
13	IEEE Transactions on Education	60	1,246	41	Q1
14	Education Sciences	60	1,922	15	Q1
15	International Journal of Information and Communication Technology Education	55	414	36	Q2
16	Technology Knowledge and Learning	46	1,162	52	Q1
17	European Journal of Engineering Education	40	486	9	Q1
18	Medical Teacher	39	1,168	9	Q1
19	Interactive Technology and Smart Education	36	702	40	Q1
20	International Journal of Innovation and Learning	35	209	15	Q3

Note. TLS: link strength & Q: Scopus quartiles in 2024

Furthermore, the result revealed that Turkey is in the fourteenth rank in **Table 2**, and Indonesia contributes less than other countries in the region. In addition, the findings showed that only South Africa from the African continent is on this list, with 123 documents and 92 connections. This result shows that contributions in ICT on the African continent are limited, except in South Africa.

Regarding the Australian continent, it is a highly influential regional leader with 279 documents, 11,835 citations, and 2,15 links. It performs strongly in terms of the number of records and international collaborations.

Table 3 presents the twenty leading journals regarding ICT publications in higher education. We found that 4,348 articles were published across 709 distinct journals. Regarding Journals with the most publications, the results in **Table 3** reveal that Computers and Education (276 documents) is the clear leader. With a total of 33,369 citations and a total link strength of 641, it ranks at the top in both productivity and impact. It is also the leader with both a high number of documents and impact per publication. After this journal, International

Table 4. Twenty most cited authors

Rank	Authors	Countries	Documents	Total citations
1	Jurgen Rudolph	Singapore	3	1,319
2	Shannon Tan	Singapore	3	1,319
3	Samson Tan	Singapore	2	1,312
4	Allison Littlejohn	UK	2	1,120
5	Shane Dawson	Australia	4	973
6	Gwo-Jen Hwang	Taiwan	12	935
7	Michael M. Grant	USA	2	916
8	Joanne Gikas	USA	1	886
9	Thomas A. Brush	USA	2	880
10	James Herman	USA	1	826
11	Michelle McDaniel	USA	1	826
12	M.D. Roblyer	USA	1	826
13	Marsena Webb	USA	1	826
14	James Vince Witty	USA	2	822
15	Hyo-Jeong So	South Korea	1	742
16	Niki E. Davis	New Zealand	1	742
17	Joyce W. Gikandi	Kenya	1	742
18	D. Morrow	New Zealand	1	731
19	Jongpil Cheon	USA	1	731
20	Steven M. Crooks	USA	1	731

Journal of Emerging Technologies in Learning (231 documents) is in second place but has a lower impact in terms of total citations and link strength. Another one with the most publications is Sustainability (Switzerland), with 200 documents. It ranks third, with a total of 6,647 citations, and is classified in the Q1 category.

Our results regarding citation impact and publication quality show that Computers and Education is the leader, boasting both a high number of papers and a high impact per publication. Also, the British Journal of Educational Technology and Internet and Higher Education are notable for their high citation numbers. The Internet and Higher Education have a high impact per publication with 9,511 citations and 90 documents.

Regarding Scopus quartile status, the results demonstrate that most journals are in the Q1 category, indicating that these journals publish high-quality publications. The database has 14 journals in the Q1 category, three in the Q2 category, and two in the Q3 category.

The results regarding link strength show that Computers and Education (641) and British Journal of Educational Technology (234) have the highest values for link strength. This suggests that these journals play a crucial role in facilitating international collaborations and enhancing citationality. Among publications on ICT, there exist medical and engineering education journals. Among the first 20 journals, BMC Medical Education, Journal of Surgical Education, and Medical Teacher are prominent journals in medical education. In addition, the International Journal of Engineering Education stands out as the most contributing journal in the field of engineering education.

Regarding journal categories, our results revealed that four categories exist. First, Computers and Education, British Journal of Educational Technology, Education and Information Technologies, Technology, Knowledge and Learning, Internet and Higher Education, and International Journal of Emerging Technologies in Learning, as well as Interactive Technology and Smart Education, are leading journals in the field of educational technology. Second, the International Journal of Engineering Education, Computer Applications in Engineering Education, and the European Journal of Engineering Education are leading journals in engineering education. Third, BMC Medical Education, Journal of Surgical Education, and Medical Teacher are important contributing journals in the field of medical education. Fourth, Sustainability (Switzerland), Cogent Education, International Journal of Innovation and Learning, and Education Sciences appeal to a wide audience with their multidisciplinary approaches.

Most Cited Authors

Our results revealed contributions from 12884 authors across various countries that contributed to ICT research in higher education. **Table 4** presents the twenty most-cited authors. Of these authors, 10 were from

Table 5. Ten most cited documents

Rank	Document title	Journals	Authors	Year	Citation
1	ChatGPT: Bullshit spewer or the end of traditional assessments in higher education?	Journal of Applied Learning & Teaching	Rudolph et al. (2023)	2023	901
2	Mobile computing devices in higher education: Student perspectives on learning with cellphones, smartphones & social media	The Internet and Higher Education	Gikas and Grant (2013)	2013	886
3	Findings on Facebook in higher education: A comparison of college faculty and student uses and perceptions of social networking sites	The Internet and Higher Education	Roblyer et al. (2010)	2010	826
4	Student perceptions of collaborative learning, social presence and satisfaction in a blended learning environment: Relationships and critical factors	Computers & Education	So and Brush (2008)	2008	812
5	Online formative assessment in higher education: A review of the literature	Computers & Education	Gikandi et al. (2011)	2011	742
6	An investigation of mobile learning readiness in higher education based on the theory of planned behavior	Computers & Education	Cheon et al. (2012	2012	731
7	Are digital natives a myth or reality? University students' use of digital technologies	Computers & Education	Margaryan et al. (2011)	2011	679
8	Can we teach digital natives digital literacy?	Computers & Education	Ng (2012)	2012	671
9	Online teaching and learning in higher education during the coronavirus pandemic: Students' perspective	Sustainability	Coman et al. (2020)	2020	655
10	Collaborating with ChatGPT: Considering the implications of generative artificial intelligence for journalism and media education	Journalism & Mass Communication Educator	Pavlik (2023)	2023	550

the USA, three from Singapore, and two from New Zealand. Other countries, including Australia, Kenya, South Korea, Taiwan, and the UK, have one author.

Regarding the most cited authors, our results showed that Shane Dawson (Australia) has the highest total number of citations, with 4 documents and 973 citations. This suggests that he has a significant academic impact on ICT research in higher education. Joanne Gikas (USA) also has a high impact per publication with 1 document and 886 citations. Furthermore, the results show a strong representation of researchers from Singapore in the field of ICT. Authors such as Jürgen Rudolph, Shannon Tan, and Samson Tan showed a strong influence in the field of ICT. These authors stand out both in terms of the number of documents and citations (see **Table 4**).

In addition, Gwo-Jen Hwang (Taiwan) is the author with the highest number of publications, with 12 documents and 935 citations. This underlines her productivity and academic contribution. Authors such as Allison Littlejohn (UK) and Hyo-Jeong So (South Korea) stand out as strong representatives from different countries. On the other hand, the results also show that many authors from the USA, such as Michael M. Grant, Thomas A. Brush, and James Herman, are on the list with notable contributions in terms of total number of citations and contributions to papers. In terms of influence per publication, the results show that Joanne Gikas stands out with a high number of citations per publication. This suggests that her work has a significant impact on ICT research in higher education.

Most Cited Documents

Our analysis of the most cited documents aimed to identify critical publications and emerging trends. **Table 5** shows the ten most-cited articles. Results have shown that the first most cited article entitled "ChatGPT: Bullshit spewer or the end of traditional assessments in higher education?" written by Rudolph et al. (2023) has the highest number of citations (901). This suggests a significant interest in the impact of ChatGPT on education. The second most cited article, titled "Mobile computing devices in higher education," was written by Gikas and Grant (2013). The third most cited article, entitled "Findings on Facebook in higher education," written by Roblyer et al. (2010), has made important contributions to the role of technology in education. Results also showed that five studies published in Computers and Education are highly cited in the ICT research in higher education. This suggests that the Computers and Education journal is a valuable resource on ICT. In addition, two articles were published on The Internet and Higher Education. The other

Table 6. The 10 most highly co-cited documents in the database

Rank	Documents	CC
1	Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-340. https://doi.org/10.2307/249008	81
2	Muller, K., & Cohen, J. (1989). Statistical power analysis for the behavioral sciences. *Technometrics, 31*(4), 499-500. https://doi.org/10.2307/1270020	79
3	Bloch, M., Lave, J., & Wenger, E. (1994). Situated learning: Legitimate peripheral participation. *Man, 29*(2), 487-488. https://doi.org/10.2307/2804509	63
4	Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa	62
5	Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982-1003. https://doi.org/10.1287/mnsc.35.8.982	61
6	Venkatesh, N., Morris, N., Davis, N., & Davis, N. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425-478. https://doi.org/10.2307/30036540	61
7	Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39-50. https://doi.org/10.1177/002224378101800104	61
8	Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science, 46*(2), 186-204. https://doi.org/10.1287/mnsc.46.2.186.11926	44
9	Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall, Inc.	44
10	Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211. https://doi.org/10.1016/0749-5978(91)90020-T	39

Note. CC: Co-citation

journals are Journal of Applied Learning and Teaching, Sustainability (Switzerland), and Journalism and Mass Communication Educator.

Among the most cited articles, many address the use of ICT. For example, titles such as "Mobile computing devices in higher education" and "Findings on Facebook in higher education" discuss the impact of mobile devices and social media platforms on education. "Online teaching and learning in higher education during the coronavirus pandemic" emphasizes the importance of online education during the pandemic. Furthermore, "Can we teach digital natives digital literacy?" and "Are digital natives a myth or reality?" question digital literacy and the adaptation of younger generations to technology. These articles point to the challenges and opportunities facing educators in the digital age. In addition, "ChatGPT: Bullshit spewer or the end of traditional assessments in higher education?" and "Collaborating with ChatGPT" address the potential impact of AI in education and a curiosity about how AI can transform traditional methods in education. Furthermore, "Student perceptions of collaborative learning, social presence, and satisfaction in a blended learning environment" discusses students' educational experiences and their impact on satisfaction. Finally, "Online formative assessment in higher education" and "An investigation of mobile learning readiness in higher education" focus on assessment and learning readiness.

Furthermore, the results revealed that an article entitled "Collaborating with ChatGPT," written by Pavlik (2023), was among the most cited documents. This article opens a new area of research by addressing the potential impacts of artificial intelligence in education.

Co-Citation Analysis

Using co-citation analysis, we identified the most co-cited documents in ICT research in higher education to evaluate scholarly impact and patterns. **Table 6** lists the top 10 papers that were most co-cited in the analyzed documents. The results revealed that the highly co-cited documents span the period from 1981 to 2006. Of the top 10 papers, only three articles were published after 2000, such as Braun and Clarke (2006), Venkatesh et al. (2003), and Venkatesh and Davis (2000). The other most co-cited documents were published before 2000, and they were methodological or conceptual papers to examine learners' affective and behavioral learning outcomes in ICT research and higher education.

Generally, these articles explore various theoretical approaches and methodologies. These articles focused more on topics such as technology acceptance, learning theories, statistical analysis, and behavioral models. Some of these articles focused on technology acceptance and user behavior. Davis (1989), Davis et al. (1989), Venkatesh and Davis (2000), and Venkatesh et al. (2003) looked at technology acceptance and user behavior. These studies focused in particular on the technology acceptance model and its extended versions.

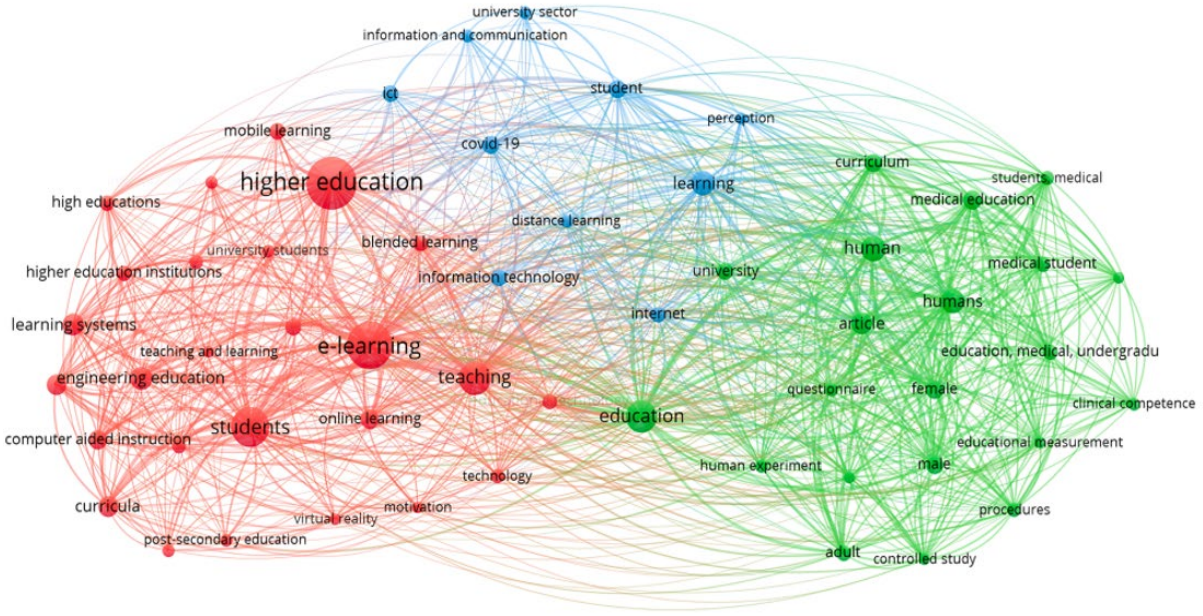

Figure 2. The major research topics according to the most used keywords (Source: The authors' data)

By examining university students' perceptions of technology use (e.g., perceived usefulness and ease of use), they sought to understand the critical factors for technology adoption.

Another group of studies, such as those by Ajzen (1991) and Bandura (1986), provided theoretical frameworks that influence individual behavior. Ajzen's (1991) theory of planned behavior emphasizes the influence of individual intentions on behavior, while Bandura's social cognitive theory explains how individuals interact with the environment and personal factors. In the documents analyzed, the researchers used Ajzen's (1991) and Bandura's (1986) theories to examine the technology acceptance and learning processes of students and teachers.

Another group of studies, conducted by researchers such as Fornell and Larcker (1981) and Muller and Cohen (1989), used statistical analysis methods commonly used in the behavioral sciences, including structural equation modeling and statistical power analysis, to examine the relationships between variables. Researchers such as Bloch et al. (1994) and Braun and Clarke (2006) are widely cited by researchers for their theoretical and methodological contributions to the field of learning and psychology. While Bloch et al. (1994) emphasized the social context of learning with situated learning theory, Braun and Clarke (2006) contributed to qualitative research methods with thematic analysis.

Another finding is that Braun and Clarke (2006) focused on qualitative data analysis, while studies such as Fornell and Larcker (1981) developed quantitative methods of analysis. This finding is noteworthy as it shows that the methodological approaches used in ICT research include both quantitative and qualitative data analysis. As a result, it appears that all of these studies serve to understand learner behavior concerning ICT. Furthermore, the findings of these studies suggest that ICT researchers use a range of theoretical frameworks, methods, and application areas.

Main Research Topics in the Field of GCE

The analysis of keyword co-occurrence enables the identification of primary research topics and themes, as well as their relationships with other themes within the analyzed documents. **Figure 2** shows the size of the nodes reflecting the frequency of occurrence of the keywords to illustrate the importance of each keyword. Our analysis resulted in a total of 15,790 keywords. Among these keywords, we analyzed 57 keywords that were used at least 100 times in the analyzed documents. **Table 7** presents the three most important research themes identified in the clusters.

The first cluster (see cluster 1, red color in **Figure 2**) included 26 keywords in **Table 7** and focuses on educational transformation and innovation, addressing the impact of ICT in higher education from both

Table 7. Main topics and related topics in the field of GCE

Main topics	Related topics
Educational transformation and innovation through ICT	Blended learning, computer aided instruction, curricula, distance education, e-learning, education computing, engineering education, high education, higher education, higher education institutions, information and communication, learning management, learning systems, mobile learning, motivation, online learning, post-secondary education, students, surveys, teaching, teaching and learning, technology, undergraduate students, university students, virtual reality
Role of technology in medical education	Adult, article, clinical competence, computer assisted instruction, controlled study, curriculum, education, education-medical-undergraduate, educational measurement, female, human, human experiment, humans, male, medical education, medical student, organization and management, procedures, questionnaire, students-medical, university
The role of ICT during the COVID-19 pandemic	COVID-19, distance learning, ICT, information and communication technology, information technology, internet, learning, perception, student, university sector

theoretical and practical perspectives. Keywords in the first cluster, such as blended learning, e-learning, distance education, and online learning, are directly related to the digitalization of learning processes and the flexibility that technology offers in education. The use of these keywords explains the direction of research on ICT in higher education. In addition, keywords, computer-aided instruction, education computing, and learning systems show how technological tools and software were used in education to support learning processes, to enrich and make learning materials interactive for undergraduate students. Furthermore, the results regarding mobile learning and virtual reality keywords address learning experiences to increase undergraduate students' motivation and enhance learning effectiveness. In addition, keywords such as motivation, teaching and learning, and learning management reveal how technology can be used as part of pedagogical strategies. These keywords highlight the crucial role of ICT in higher education. Overall, these keywords in the first cluster provide evidence of a research trend for educational transformation and innovation by addressing the impact of ICT in higher education.

Cluster two (see cluster 1, indicated by the green color in **Figure 2**) included 21 keywords, as listed in **Table 7**. These keywords include adult, article, clinical competence, computer-assisted instruction, controlled study, curriculum, education, education-medical-undergraduate, educational measurement, female, human, human experiment, humans, male, medical education, medical student, organization and management, procedures, questionnaire, students-medical, and university. The research in this cluster shows a strong interest in medical education and health. Keywords such as "medical education", "medical student," and "medical students" show that research on ICT focuses on the education and development of medical students. Also, keywords of "clinical competence" and "procedures" emphasize the importance of practical experiences in education for practical skills and the development of clinical competence. Similarly, keywords such as computer-assisted instruction and educational measurement refer to the integration of technology into medical education for assessing learning outcomes. Furthermore, research-oriented keywords such as questionnaire and controlled study represent tools and approaches for methods used in education. In addition, keywords such as 'adult' and 'human experiment' refer to adult learning theories and experimental studies involving human participants, while 'organization' and 'management' focus on the planning, implementation, and management of medical education. Lastly, these keywords in the second cluster address topics like the growth of students' clinical competency, the assessment of educational procedures, and the use of technology in the classroom to raise student achievement and enhance ICT-based health professional training.

Cluster three (see cluster 1, indicated by the blue color in **Figure 2**) includes COVID-19, distance learning, ICT, information technology, internet, learning, perception, student, and the university sector. These keywords address the role of ICT during the COVID-19 pandemic. This finding also means that ICT is a critical enabler of this change in higher education. Similarly, in this cluster, keywords such as internet and learning refer to the migration of learning processes to digital platforms and the internet to facilitate students' access to online courses and information. Additionally, keywords such as 'perception' and 'student' are important terms for understanding students' perceptions and experiences in distance learning and technology use during the pandemic. Overall, these keywords offer a framework for comprehending how ICT influenced remote learning procedures and played a crucial role in higher education during the COVID-19 pandemic.

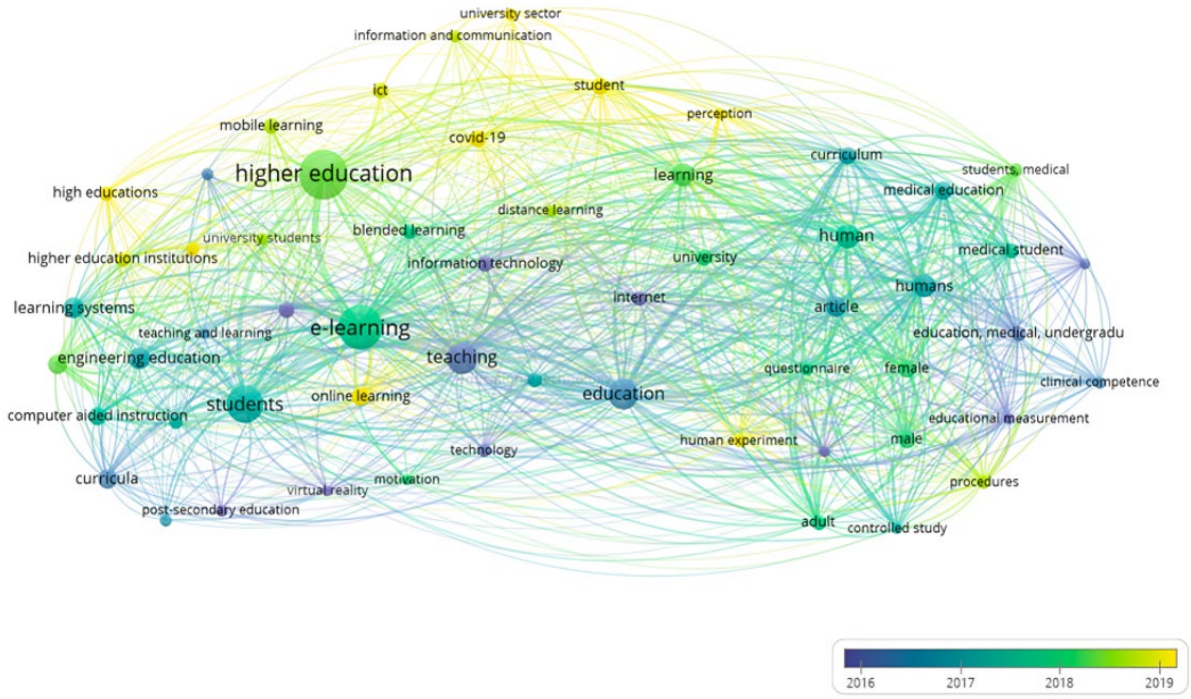

Figure 3. Change of ICT research over the years (Source: The authors' data)

Figure 3 shows a change in the direction of ICT research. The results in **Figure 3** show that after 2019, some key words, including COVID-19, student, perception, and online learning, were used most frequently by researchers in ICT research. From this, we can conclude that research has focused on understanding higher education students' perceptions of online learning, especially after the COVID-19 pandemic.

CONCLUSION

The present study aimed to analyze patterns and research trends related to ICT in higher education from 2005 to 2024. The results revealed that the number of publications showed a continued increase after 2008 until 2024. This development in the number of articles has prompted researchers to study and implement ICT in various national contexts, leading to a peak in 2021. The increasing development of technology has encouraged the use of ICT in higher education.

In terms of publication output by country, our results show that North America, and the USA in particular, lead the world in terms of both productivity and impact in the field of ICT in higher education. In Europe, Spain and the UK stand out, while in Asia, China has taken the lead, with Malaysia and India standing out with strong academic contributions and collaborations. On the African continent, only South Africa is represented, while Australia stands out as a strong regional leader with international collaborations and great academic influence. These results may be attributed to the significant theoretical contributions to educational technology made by researchers from these countries. The support of prestigious universities in promoting ICT research in these countries may also be a contributing factor to this result.

The lack of publications on ICT from South American and African countries (except South Africa) indicates a potential gap in cooperation networks. Our results show that the geopolitical context can also influence the situation of research on ICTs. This finding points to a research gap in the field of ICT studies. To fill this gap, researchers from non-Western countries, South American countries, and African countries need to encourage the conduct of more studies on the use of ICTs in higher education. Such an approach could encourage researchers working in these countries to provide more evidence on ICT at an international level. Among the numerous academic journals, Computers and Education stands out as a leading entity. This journal, which focuses on the intersection of computers and education, has the highest number of citations among its peers. Its main focus is on researchers conducting studies on all aspects of educational technology research on computers. The following two journals are the International Journal of Emerging Technologies in Learning and

Sustainability (Switzerland). The presence of influential articles in these journals underlines the importance of the publications within the academic community and the wider practice of ICT research.

The analysis of the most cited authors revealed that all authors come from developed countries, except one author from Kenya. The authors from developed countries are from Australia, Singapore, South Korea, New Zealand, Taiwan, the UK, and the USA. Our results suggest that this finding can be seen in the context of technological development in these countries and that researchers in developed countries can produce more influential studies on topics such as ICT. In light of these results, our findings emphasize the importance of technological advancement for educational technology research. Our examination of the most frequently cited documents revealed critical studies published between 1981 and 2006 that specifically address topics such as technology acceptance, learning theories, behavioral models, and statistical analysis. The studies, which used both qualitative and quantitative methods, provided a variety of theoretical frameworks for understanding technology use and learning processes. Overall, these studies demonstrate a wide range of methodological and theoretical approaches to understanding individual technological acceptance and learning behavior about ICT in higher education.

Overall, the results of this study show that ICT has become an important topic in education over the last two decades. Nevertheless, there is still a clear imbalance between Western and non-Western countries in terms of contributions. Thus, there is an urgent need for contributions from a wider range of researchers to redress this imbalance in ICT research in higher education. In addition, the findings of this study contribute to knowledge growth for researchers and educational practitioners by summarizing information from different perspectives on the use of ICT in higher education.

Our results regarding research topics and trends show three clusters in the analyzed documents. The first research trend in cluster one focused on change and innovation in education and showed a research trend for educational transformation and innovation by addressing the impact of ICT in higher education. The research trend in cluster two emphasized the role of ICT in medical education and showed a research trend on the use of technology in the classroom to enhance student achievement and improve ICT-enabled health professional education. In addition, the research trend in cluster three addressed the role of ICT in education during the pandemic and provided evidence of how ICT influenced distance learning practices and played a crucial role in higher education during the COVID-19 pandemic. Finally, our findings regarding research between 2016 and 2024 show that post-2019 research has focused on understanding higher education students' perceptions of online learning, particularly in the aftermath of the COVID-19 pandemic.

Limitations

This research has limitations. The first limitation arises from the fact that this study used data from the Scopus database. Due to this limitation, our results should be interpreted in light of this limitation. The second limitation is that we employed specific analysis parameters such as the most cited documents and co-cited documents. The use of other analysis parameters may show different results for authors, countries, and documents. The third limitation is that we only considered documents published in English. We excluded documents published in languages other than English. This limitation may have resulted in several important documents on ICT and higher education not being included.

Recommendations

The results of this study show that the steady increase in the number of publications on ICT since 2008 indicates a growing interest in this field. In light of these findings, researchers can keep their research topics up to date by following the themes that have emerged in recent years. In particular, the three main research clusters that have emerged between 2005 and 2024 in terms of research trends in this study serve as a guide for researchers. In this respect, researchers can shape their future work based on the research trends that emerge from our findings.

In addition, our findings show that the COVID-19 pandemic has accelerated the adoption of distance learning and digital learning tools. One of the three themes that have emerged in terms of research trends is the COVID-19 pandemic. In this context, investigating the impact of ICT use on learning and teaching in higher education during this pandemic represents a significant research opportunity for researchers. Another finding from this study is that scientific journals with a high impact factor publish the most frequently cited

studies on ICT. Based on this finding, we recommend that researchers review the publication policies of such journals and prepare their studies according to these standards.

Our findings show that research on ICT is more intensive in developed countries. Against this background, researchers working in developing countries can make an important contribution to improving equity in education by focusing their work on the integration of ICT in higher education. Furthermore, the fact that the most frequently cited authors are from developed countries underlines the importance of international cooperation. Therefore, universities can encourage researchers working on ICT to expand their global networks and collaborate with academics from different countries.

Additionally, we suggest that future research should consider the use of multiple databases to gain a more comprehensive understanding of the use of ICT in higher education. Furthermore, examining the role of new technologies such as artificial intelligence and big data analytics, which have been rapidly developing in recent years, in the use of ICT and developing innovative teaching activities is an area of research that researchers should work on. Finally, it may be of greater benefit to examine the impact of ICT in higher education in more specific areas (e.g., STEM, social sciences, and arts). In particular, research into the long-term impact and sustainability of distance learning after the pandemic may be important both as a contribution to the existing literature and for conducting innovative studies.

Author contributions: RGS: conceptualization, methodology, supervision, writing – original draft, writing – review & editing; **EEG:** data curation, formal analysis, writing – original draft; **ERK:** investigation, visualization, resources; **MAZ:** project administration, writing – original draft, writing – review & editing; validation; **EGS:** software, data curation, visualization, writing – original draft; **NIL:** resources, formal analysis; **OVK:** software, data curation, visualization, writing – original draft. All authors approved the final version of the article.

Funding: The authors received no financial support for the research and/or authorship of this article.

Ethics declaration: Since this study is a literature review, ethical committee approval was not necessary. However, the research was carried out in strict accordance with all relevant ethical principles and guidelines.

Declaration of interest: The authors declared no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

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