Contemporary Educational Technology, 2026, **18**(4), ep684
ISSN: 1309-517X (Online)

OPEN ACCESS

Review Article

Implications of educational technology: A bibliometric analysis of the top 100 most cited studies over twenty years

Oksana V. Vashetina [1*]
0000-0001-5021-9228

Tatyana Shoustikova [2]
0000-0002-0404-6693

Natalia A. Zaitseva [3]
0000-0002-0048-5509

Yelizaveta V. Chereshneva [4]
0000-0002-1046-6336

Mariia S. Pavlova [4]
0000-0001-6494-6311

Zhanna M. Sizova [4]
0000-0002-1242-7074

Andrey V. Suslov [4,5]
0000-0003-0613-8556

[1] Kazan Federal University, Kazan, RUSSIA
[2] Peoples' Friendship University of Russia named after Patrice Lumumba, Moscow, RUSSIA
[3] Plekhanov Russian University of Economics, Moscow, RUSSIA
[4] Sechenov First Moscow State Medical University, Moscow, RUSSIA
[5] National Medical Research Center of Cardiology, Moscow, RUSSIA
[*] Corresponding author: vashetina@yandex.ru

Citation: Vashetina, O. V., Shoustikova, T., Zaitseva, N. A., Chereshneva, Y. V., Pavlova, M. S., Sizova, Z. M., & Suslov, A. V. (2026). Implications of educational technology: A bibliometric analysis of the top 100 most cited studies over twenty years. *Contemporary Educational Technology, 18*(4), Article ep684. https://doi.org/10.30935/cedtech/19183

ARTICLE INFO

Received: 28 Jan 2026
Accepted: 12 Aug 2026

ABSTRACT

Educational technology (ET) plays an important role in improving student learning experiences, yet no prior study has systematically examined research trends among its most influential publications. This bibliometric study analyzed the 100 most-cited articles on ET published between 2005 and 2024, drawn from the Scopus database. Results show that articles published in 2020 received the highest total citations, with the USA, Taiwan, and Australia as the most productive countries and Computers and Education as the leading source journal. Analysis of the top 20 most-cited articles identified three themes: interactive learning environments, the role of digital technologies, and the impact of the COVID-19 pandemic on ET use. Keyword co-occurrence analysis further revealed four emerging research clusters spanning technology acceptance, learning-process monitoring, distance-learning pedagogy, and post-pandemic online/blended learning models. Co-citation analysis showed that researchers most frequently drew on studies addressing individual learner characteristics and technology acceptance frameworks (TAM/UTAUT). These findings offer researchers and practitioners a consolidated overview of the field's most impactful contributions and emerging directions.

Keywords: educational technology, most cited studies, bibliometric analysis, 100 most cited, TAM, UTAUT

INTRODUCTION

Educational technology (ET) plays an important role in enhancing students' learning experiences and outcomes at each school level and facilitates the adoption of new pedagogical methods and techniques that promote learners' active engagement. A substantial number of studies have reported that integrating technology into educational settings can significantly improve students' learning outcomes and their affective variables. In addition, ET helps learners create a more personalized learning environment tailored to their own pace and needs (Ali, 2024). Moreover, ET is beneficial for teachers and instructors in assessing and monitoring students' learning outcomes and progress. Furthermore, ET fosters more extensive access for students and teachers to resources and information regarding course topics. Particularly, the COVID-19 pandemic further helped all stakeholders of education to make learning more flexible and responsive to their needs (Balaji & Sahija, 2022).

In addition to these benefits of ET for learners and instructors, its use has helped to provide skill development pertinent to the 21st century (Masveta, 2026; Mena-Guacas et al., 2023; Olszewski & Crompton, 2020). For example, research has reported that the use of ICT tools promotes critical thinking and fosters collaboration among students, essential skills in today's interconnected world (Liesa-Orús et al., 2020). To examine the benefits and contributions of ET for learners and instructors, researchers have conducted many studies to understand the effects of ET applications on learners and instructors. For this aim, a huge number of publications have been conducted. Also, the most effective publications have been conducted to shed light on researchers about the contribution of ET. However, no research examined a review of the 100 most cited publications that were produced to report on the effects of ET and research trends among these publications. Despite the growing number of bibliometric studies in various ET subfields, only a limited number of studies have specifically examined the top 100 most-cited articles in ET as a whole (Mohsen et al., 2025). This gap indicates a need for a comprehensive bibliometric investigation that maps the most influential publications, dominant themes, and contributing countries and authors in this field, which the present study aims to address.

Researchers have also emphasized the importance and value of conducting bibliometric analysis to examine research trends in ET (C. C. Chen et al., 2022; Ishmuradova et al., 2024; Mahdavinasab & Haseli, 2025). For example, C. C. Chen et al. (2022) analyzed the 100 most cited articles on information literacy (IL) in higher education and the research trends between 2011 and 2020. Their study revealed four main research directions on

(a) the relationships between students' IL beliefs, competencies, attitudes, and behaviors;

(b) students and instructors' perspectives;

(c) the relationship between IL and epistemic beliefs; and

(d) behaviors in web search.

Mahdavinasab and Haseli (2025) also conducted a bibliometric analysis to explore the conceptual structure and trending topics of articles published in the Education and Information Technologies Journal. They analyzed 3,171 publications published from 1996 to 2023. Their analysis revealed nine subject areas of Education and Information Technologies Journal including role of ICT and technology in education, blended learning and teacher training, e-learning and mobile learning, engaging and motivating learning environments, educational data mining and machine learning, distance education in different academic settings, education during the COVID-19 pandemic, ET in higher education, and the use of social media in education. Another research by Darmawansah (2021) analyzed research trends on ET in Indonesia among publications published between 2011 and 2020 using bibliometric analysis. The results revealed that in terms of the most-cited journals (citation analysis), the Australasian Journal of Educational Technology was the leader, and the Computers and Education journal was the most-cited based on co-citation analysis. Another research by Jiménez et al. (2019) assessed the publications of ET in higher education in the Web of Science database using bibliometric analysis. Their analysis found a significant increase in the number of publications on ET and indicated that there will be a growing trend in publications on ET after 2019. Results from these studies (C. C. Chen et al., 2022; Darmawansah, 2021; Jiménez et al., 2019; Mahdavinasab & Haseli, 2025) reveal that the number of publications and academic interest in the fields of IL and ET are steadily increasing by

Table 1. A list of keywords used for searching in the database

No	Educational technology	Learning and teaching
1	Technology-enhanced learning	Learning
2	Digital learning	Teaching
3	E-learning	Instruction
4	Online education	Pedagogy
5	Instructional technology	Curriculum
6	Learning technologies	Training
7	Educational media	Educational practice
8	ICT in education	Instructional design
9	VLEs	Educational methods
10	Blended learning	Formal education

identifying research trends, main topics, and the most cited publications and journals through bibliometric analyses.

Recently, scholars have emphasized the value of analyzing publications in identifying research trends (C. C. Chen et al., 2022; Darmawansah, 2021; Mahdavinasab & Haseli, 2025) and in using bibliometric analysis to determine research trends (Ishmuradova et al., 2024; Özel, 2024). For example, C. C. Chen et al. (2022) analyzed the research trends in the top 100 most cited articles on IL published from 2011 to 2020 in higher education. Other researchers (Chen et al., 2023; Hossein-Mohand et al., 2025; Kilavuz, 2024) have argued that such review studies enable researchers to quickly understand research topics and trends and follow recent developments in a particular field. Particularly, Jiménez et al. (2019) identified a significant increase in ET publications in higher education and predicted that this trend would increase even further after 2019. Although some studies (e. g., Darmawansah, 2021; Mahdavinasab & Haseli, 2025; V. Chen et al., 2022) assessed the research trends and topics about research on ET, what is missing from these studies is that no studies have been conducted and examined to examine research trends on the 100 most-cited articles published on ET in the literature. Hence, this study analyzed the top 100 most frequently cited articles on ET in the Scopus database and explored the research trends. The main research questions that the authors sought to answer in this study were as follows: What are the main research trends revealed in the top 100 cited articles on ET?

METHOD

Searching Strategy and Data Collection

The authors searched for the Scopus database to collect data to answer the research questions. We completed the search of the database in July 2025. **Table 1** shows a list of keywords the authors used during the search in the database. In addition, the search we conducted is: TITLE-ABS-KEY ((“educational technology” OR “technology-enhanced learning” OR “e-learning” OR “digital learning” OR “online education” OR “instructional technology” OR “ICT in education” OR “learning technologies” OR “virtual learning environments” OR “blended learning”) AND (“education” OR “teaching” OR “instruction” OR “pedagogy” OR “curriculum” OR “educational practice” OR “instructional design” OR “training” OR “learning” OR “educational methods”)).

Regarding the time range of the data collection, we used the last twenty years, from 2005 to 2024. Thus, publications published in 2025 were not included in the data analysis in the study. We obtained all information regarding the articles’ publication types, including journal articles and conference articles, author information, citation information, and publication information from the Scopus database after completing the search in the database in July 2025. We conducted all analyses based on the basis of the data obtained from the Scopus database to prevent biases caused by the update of the citation information. To achieve this, we sorted all included articles by citation number in order from highest to lowest in the database. Studies that met the following exclusion criteria were excluded from extraction and further analysis: (1) studies not related to any ET. Thus, we involved only studies focusing on ET that were included in the study. **Table 2** presents the inclusion and exclusion criteria for collecting data. Using these keywords, the data yielded a total of 198,265 documents. We then used the “social sciences” option as the first filter option, which reduced the number of results to 77,074. As a second filter option, we used the option “Article,” which reduced the number of publications to 37,885. As a third filter option, we used the option “Journal,” which reduced the number of

Table 2. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Articles on educational technology	Articles that do not include any aspect of educational technology.
Articles published in English	Articles that are not related to educational technology.
Articles published from 2005 to 2024	Editorials, letters to editors, early access articles
	Documents that are not placed in the top 100 cited articles.

publications to 37,625. Finally, for the publication language, "English" was selected as the fourth filter option, which reduced the number of publications to 35,498. Finally, we conducted a citation analysis in the database to determine the 100 most cited articles and ranked them according to the number of citations. The decision to focus on the top 100 most-cited articles was based on the widely adopted convention in bibliometric research, in which highly cited studies are considered to represent the most influential and field-shaping contributions to a discipline (C. C. Chen et al., 2022; Lai, 2020). Analyzing the top-cited articles allows researchers to identify dominant themes, seminal works, and citation patterns that have substantially shaped the direction of a research field. However, this approach also has certain limitations, as citation counts are influenced by factors such as publication age, journal visibility, and self-citation practices, which are addressed in the Limitations section. Thus, within the eligible studies, information about the 100 most cited studies about ET was extracted. We used Excel and the Scopus database for statistical analysis and to build figures. For bibliometric analysis, we used VOSviewer software.

Inclusion and Exclusion Criteria

In this study, we used the Scopus database to search for the top-cited 100 articles related to ET. We chose articles for analysis published in journals in the last twenty years, from 2005 to 2024. First, we searched the database for documents related to ET using keywords including ET, technology-enhanced learning, e-learning, digital learning, online education, instructional technology, ICT in education, learning technologies, virtual learning environments, and blended learning for ET. In addition, we used the keywords including education, teaching, instruction, pedagogy, curriculum, educational practice, instructional design, training, learning, and educational methods for learning and teaching.

While conducting the search in the database, we searched for articles based on title, abstract, and keywords. Second, we restricted the document type to articles, and thus we obtained the 100 top-most cited articles. Later, in the third step, we performed a manual analysis of the articles and did not include the articles that were not related to ET. After this, we did not include articles that were not written in English, and we removed them from the data. We did not include editorials, letters to the editor, correction notes, early access articles, or published articles in 2025. The screening process was carried out in three stages to ensure reliability and reproducibility. In the first stage, two researchers independently reviewed the titles and abstracts of the retrieved documents to assess their relevance to ET. In the second stage, the same researchers independently evaluated the full texts of the remaining articles against the inclusion and exclusion criteria presented in **Table 2**. Discrepancies between the two researchers were resolved through discussion, and a third researcher was consulted in cases where consensus could not be reached. This process ensured that the final sample of 100 articles consistently met the predefined inclusion criteria (see **Figure 1**).

Thematic Analysis of the Top 20 Most-Cited Articles

To identify recurring themes among the top 20 most-cited articles, we conducted an inductive thematic content analysis. Two researchers independently read the full texts of the 20 articles and coded their research focus, theoretical framework, and key findings. The initial codes were then compared, discussed, and grouped into broader categories based on conceptual similarity. Disagreements in coding were resolved through discussion until consensus was reached. Initial codes included *instructional design principles, technology type, learner variable, and pedagogical outcome*, which were then collapsed into three broader themes. For instance, Moreno and Mayer (2007) was coded under *instructional design principles* and *multimodal environments*, leading to its assignment to theme 1 (design and effectiveness of interactive multimodal learning environments). While the thematic analysis identifies content-level patterns within the most influential articles, the keyword co-occurrence analysis maps broader terminological clustering across the full sample, and the co-citation analysis identifies the intellectual base these articles draw on. Together, these three

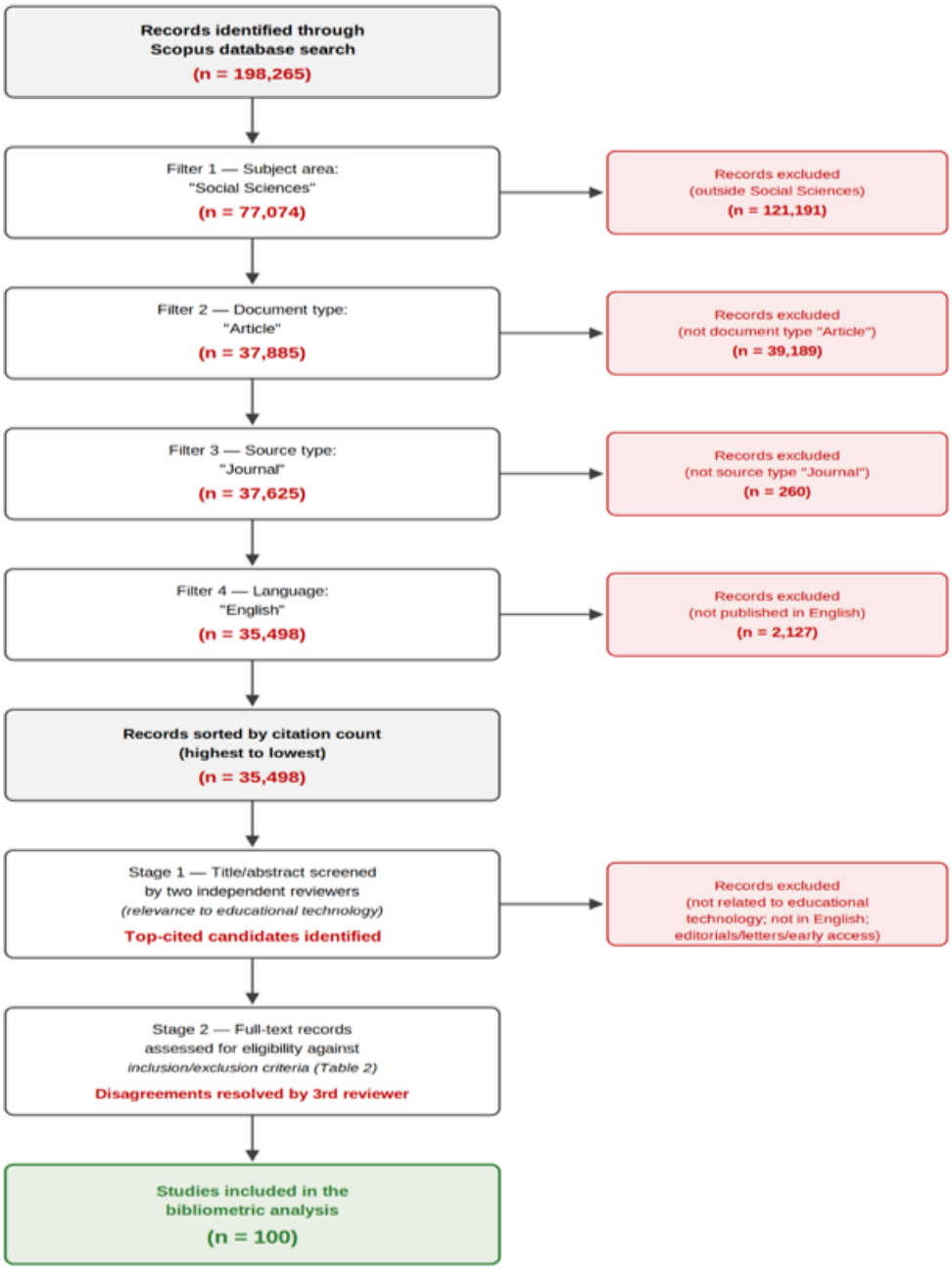

Figure 1. PRISMA flow chart (the authors' own work)

analyses provide complementary content, terminological, and intellectual-structure perspectives on the field. This process resulted in the identification of three overarching themes, as presented below.

RESULTS

Publication Years

From the Scopus database, a total of 35,498 articles were retrieved using the search term "educational technology" in the "title, abstract, and keywords" field. Of the top 100 articles with the highest cited articles on ET, all the articles were published in journals and the English language. **Figure 2** shows the distribution of the number of publications by year. Between 2005 and 2025, the count of the 100 most referenced articles was either 0 or 13, with the quantity exceeding 1 starting in 2005. Additionally, the majority of publications were published in 2010 (n = 13), followed by 2020 (n = 11), and 2009, 2012, and 2013 (n = 8).

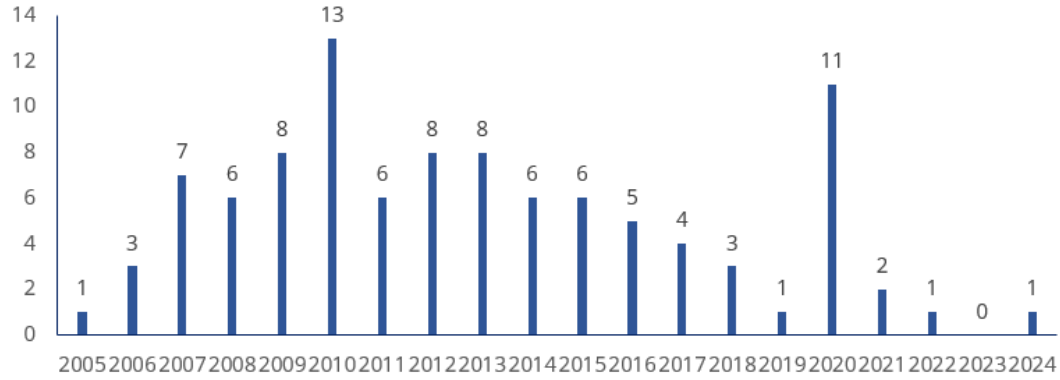

Figure 2. Yearly publishing count of the 100 most-cited articles on ET (the authors' own work)

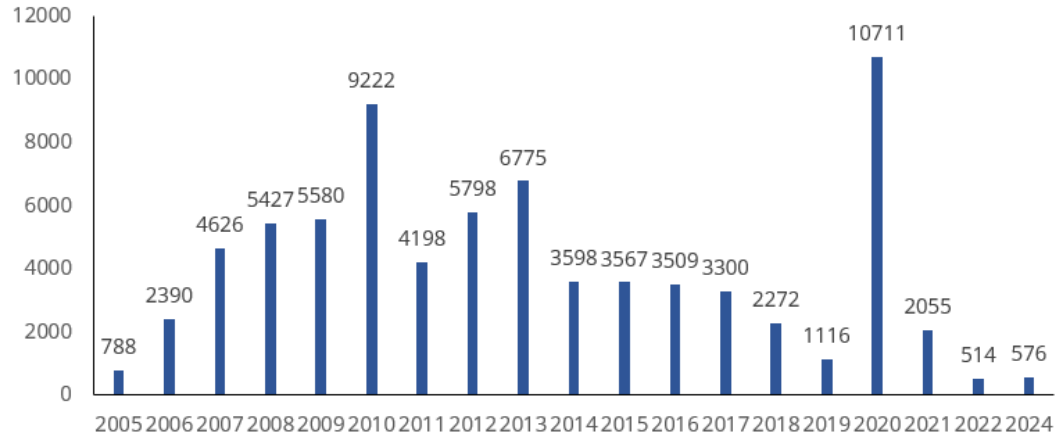

Figure 3. Total citations per annum of the 100 most-cited articles on ET (the authors' own work)

Among the 100 most-cited publications, citation frequencies varied from 498 to 1897, with a median citation count of 652. The mean citation frequency was 760.2, with 20 items cited over 1,000 times. The article with the greatest citation frequency, "*A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda*," published by Radianti et al. (2020) in Computers and Education in 2020, was cited 1,897 times.

Figure 3 shows the trend in the total number of citations by year. The year with the highest total number of citations was 2020, with 10,711, followed by 2010 with 9,222 citations, 2013 with 6,775 citations, and 2012 with 5,798 citations.

Country and Institution Analysis

In terms of the geographical distribution, the 100 most-cited articles were attributed to authors from 18 countries. The USA was the most productive country with 38 articles, followed by Taiwan with 18 articles and Spain with 6 articles, the Netherlands with 4 articles, and China, India, South Korea, Canada, and Hong Kong with three articles. According to VOSviewer analysis, a total of 299 authors from 210 institutions contributed to the 100 most-cited articles on ET. We searched the countries with publication quantities of more than three articles. **Table 3** shows a list of countries that have more than three articles. Accordingly, results yielded to 13 countries that have more than three articles. According to this analysis, results demonstrate that the USA produced the most articles and received the most citations. These results mean that publications on ET produced from the USA, both quantitative (number of articles) and qualitative (citations) contributions, are high. These results also mean that the publications ET from the USA have a significant impact. Taiwan, with 18 articles and 14,988 citations, ranks second in terms of the number of articles, but it also has a very high number of citations. This shows that publications from Taiwan have a significant impact. Similarly, Australia, with 10 articles and 9,190 citations 9,190, stands out with its high number of citations. Similarly, the UK, with 10 articles and 6,774 citations, has a big impact on ET. Furthermore, Australia and Spain have the highest

Table 3. A list of countries with over three articles

Country	Documents	Citations	Total link strength
USA	38	26,987	1,927
Taiwan	18	14,988	1,426
Australia	10	9,190	1,394
UK	10	6,774	780
Spain	6	4,901	374
South Korea	5	3,201	810
Hong Kong	4	3,230	818
Netherlands	4	2,462	433
UAE	3	2,640	661
Germany	3	2,971	249
Canada	3	2,021	204
Austria	3	1,764	149
India	3	2,371	81

Table 4. Authors of the 100 most-cited publications in ET

Author	Number of articles	Number of citations	Institution	Country
Shane Dawson	3	2,071	University of South Australia	Australia
Charles R. Graham	3	1,816	Brigham Young University	USA
Andrew P. Ciganek	2	1,053	University of Wisconsin – Whitewater	USA
Hangjung Zo	2	1,053	Korea Advanced Institute of Science & Technology	South Korea
Dragan Gasevic	2	1,238	Monash University	Australia
Shu-Sheng liaw	2	1,345	China Medical University	Taiwan
Jo Tondeur	2	1,628	Vrije Universiteit Brussel	Belgium
Punya Mishra	2	1,384	Arizona State University	USA
Gwo-Jen Hwang	2	1,033	National Taichung University of Education	Taiwan

"citation/article" ratio. Countries such as Canada, Austria, Germany, and the UAE have around 3 articles. However, their citation counts are also relatively high, indicating that the few studies are effective. Additionally, India stands out with 3 publications and 2,371 citations. Additionally, countries like India and the UAE stand out with high citation rates despite low publication numbers. This result indicates that some selected studies are significantly effective (e.g., Mishra et al., 2020).

Also, the results in **Table 3** show the total link strength. Total link strength reflects the strength of countries' international collaborations and scientific networks. A high value indicates that a country frequently publishes joint papers with other countries. For example, the USA has the highest connection strength with 1,927 links and is at the center of global research collaborations. Taiwan and Australia also stand out with their high connection strengths, demonstrating that they are important partners in regional and international research.

Author Analysis

Table 4 shows a list of authors of the 100 most-cited articles on ET. Our results yielded that a total of 299 authors were involved in the 100 most-cited articles on ET, and the authors with the number of publications more than two. The author who published the most articles was Shane Dawson, with three articles from the University of South Australia, whose name appeared in 3 of the top 100 articles. The second most published author, Charles R. Graham, came from Brigham Young University, reaching a total of three articles. The third most published authors were Andrew P. Ciganek, Hangjung Zo, Dragan Gasevic, Shu-Sheng Liaw, Jo Tondeur, Punya Mishra, and Gwo-Jen Hwang, with 2 articles each. Of these 9 authors with more than two articles and two articles, three were from the USA, two from Taiwan, one each from Australia, Belgium, South Korea, and England, and two were from China.

Journal Analysis

In total, the 100 most-cited articles on ET were published in 36 journals (**Table 5**). The journal with the highest number of publications was Computers and Education (n = 46), followed by Internet and Higher Education with 9 articles, Educational Technology & Society and British Journal of Educational Technology with 3 articles, International Review of Research in Open and Distance Learning, Educational Research Review,

Table 5. A list of journals publishing the 100 most-cited publications on ET

Journal name	Frequency
Computers and Education	46
Internet and Higher Education	9
Educational Technology and Society	3
British Journal of Educational Technology	3
International Review of Research in Open and Distance Learning	2
Educational Research Review	2
Education and Information Technologies	2
Journal of Computing in Higher Education	2
Journal of Educational Computing Research	2
CBE Life Sciences Education	2
International Journal of Technology Enhanced Learning	1
Distance Education	1
Educational Technology Research and Development	1
International Journal of Human Computer Studies	1
Medical Teacher	1
Educational Researcher	1
Learning, Media and Technology	1
Accounting, Organizations and Society	1
International Journal of Information Management	1
Human Behavior and Emerging Technologies	1
International Journal of Educational Technology in Higher Education	1
Children and Youth Services Review	1
Social Sciences and Humanities Open	1
TechTrends	1
Innovations in Education and Teaching International	1
Journal of Applied Learning and Teaching	1
Learning Environments Research	1
Educational Psychology Review	1
Eurasia Journal of Mathematics, Science and Technology Education	1
European Journal of Teacher Education	1
Higher Education for the Future	1
Journal of Research on Technology in Education	1
International Journal of Educational Research Open	1
Sustainability (Switzerland)	1
Teachers College Record	1
Computers and Education: Artificial Intelligence	1

Education and Information Technologies, Journal of Computing in Higher Education, Journal of Educational Computing Research, and CBE Life Sciences Education with 2 articles. The other 26 journals had one article in the top-cited 100 articles on ET.

Article Analysis

Table 6 shows the details of the top 20 most-cited articles. These articles were published between 2006 and 2021. They were all articles and cited more than 1,000 times. Studies in **Table 6** reveal several important patterns and themes related to the evolution and use of educational practices in the last twenty years, from 2005 to 2024. These themes can be grouped into three themes. They are

(1) interactive learning environments,

(2) the role of digital technologies, and

(3) the impact of the COVID-19 pandemic on the use of ET in instruction.

The first key theme is the design and effectiveness of interactive multimodal learning environments. For example, Moreno and Mayer (2007) proposed a cognitive-affective theory for specific design principles, including guided activity, reflection, feedback, control, and pretraining. to promote student learning. These principles highlight the importance of intentional instructional design to foster meaningful engagement and deeper learning outcomes for the use of ET in instruction (Moreno & Mayer, 2007).

Table 6. The top 20 most cited articles on ET

No	Authors	Title	Source title	N	OA
1	Radianti et al. (2020)	A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda	Computers and Education	1,897	✓
2	Sun et al. (2008)	What drives a successful e-learning? An empirical investigation of the critical factors influencing learner satisfaction	Computers and Education	1,823	X
3	Wu et al. (2013)	Current status, opportunities and challenges of augmented reality in education	Computers and Education	1,746	X
4	Bao (2020)	COVID-19 and online teaching in higher education: A case study of Peking University	Human Behavior and Emerging Technologies	1,531	✓
5	Akçayır and Akçayır (2017)	Advantages and challenges associated with augmented reality for education: A systematic review of the literature	Educational Research Review	1,525	X
6	Pokhrel and Chhetri (2021)	A literature review on Impact of COVID-19 pandemic on teaching and learning	Higher Education for the Future	1,454	✓
7	Crawford et al. (2020)	COVID-19: 20 countries' higher education intra-period digital pedagogy responses	Journal of Applied Learning and Teaching	1,407	✓
8	Domínguez et al. (2013)	Gamifying learning experiences: Practical implications and outcomes	Computers and Education	1,318	X
9	Dalgarno and Lee (2010)	What are the learning affordances of 3-D virtual environments?	British Journal of Educational Technology	1,308	X
10	Mishra et al. (2020)	Online teaching-learning in higher education during lockdown period of COVID-19 pandemic	International Journal of Educational Research Open	1,259	X
11	Ertmer et al. (2012)	Teacher beliefs and technology integration practices: A critical relationship	Computers and Education	1,185	X
12	Park and Choi (2009)	Factors influencing adult learners' decision to drop out or persist in online learning	Educational Technology and Society	1,116	X
13	Scherer et al. (2019)	The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education	Computers and Education	1,116	✓
14	Sung et al. (2016)	The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis	Computers and Education	1,090	✓
15	Roca et al. (2006)	Understanding e-learning continuance intention: An extension of the technology acceptance model	International Journal of Human Computer Studies	1,076	X
16	Moreno and Mayer (2007)	Interactive multimodal learning environments	Educational Psychology Review	1,049	X
17	Moore et al. (2011)	e-Learning, online learning, and distance learning environments: Are they the same?	Internet and Higher Education	1,048	X
18	Lee (2010)	Explaining and predicting users' continuance intention toward e-learning: An extension of the expectation-confirmation model	Computers and Education	1,030	X
19	Jensen and Konradsen (2018)	A review of the use of virtual reality head-mounted displays in education and training	Education and Information Technologies	1,025	✓
20	Strayer (2012)	How learning in an inverted classroom influences cooperation, innovation and task orientation	Learning Environments Research	1,008	X

Note. N: Number of citations; OA: Open access; & ✓ indicates that the publication is open access, while X indicates that the publication is not open access

This view aligns with Dalgarno and Lee's (2009) findings on the capabilities of 3-D virtual environments (VLEs) to enhance educational experiences. They indicated that the effective use of VLEs depends on ongoing research to clarify how the features of these environments relate to their learning benefits, to implement the design, development, and use of 3-D VLEs for learning (Dalgarno & Lee, 2009). Furthermore, Radianti et al. (2020) examined virtual reality (VR) applications in higher education using a systematic mapping method to reveal the design elements, learning content, and relationship with learning theories of existing research. Their findings show that learning theories are generally overlooked in VR applications, evaluations tend to focus on usability, and VR mostly remains at an experimental level. However, they suggested 18 different application areas for the implementation of VR technology in many disciplines. Sun et al (2008) developed an integrated model consisting of six dimensions to identify the factors affecting user satisfaction in e-learning. Their results revealed that computer anxiety, instructor attitude, course flexibility and quality, perceived

benefit, ease of use, and assessment diversity are critical factors affecting satisfaction. In another research, Ertmer et al. (2012) examined the alignment between the pedagogical beliefs of 12 teachers who were successful in using technology and their classroom technology applications. The findings showed that student-centered beliefs strongly align with student-centered practices such as authenticity, student choice, and collaboration. Furthermore, they found that teachers' attitudes toward technology, their intrinsic motivation, and environmental support are decisive in shaping their practices, while the greatest obstacle is other teachers' negative attitudes toward technology and their insufficient knowledge levels. Wu et al. (2013) argued that treating augmented reality (AR) as a conceptual framework rather than a type of technology would be more effective for educators and designers. They emphasized that alignment between technology design, teaching approach, and learning experience is critical for AR systems to enable effective learning, and classifies three teaching approaches based on roles, tasks, and spaces. Park and Choi (2009) conducted research to explain the processes of university students' adoption and use of e-learning, and data obtained from 628 students were analyzed using structural equation modeling. Based on the technology acceptance model (TAM), the model identified e-learning self-efficacy and subjective norms as the variables that most strongly influence the acceptance process. The findings revealed that the TAM model is an effective theoretical tool for understanding e-learning user acceptance. Roca et al. (2016) proposed a differentiated TAM that separates perceived performance in the context of e-learning services into "perceived quality" and "perceived usability." Data obtained from 172 participants revealed that users' intention to continue was determined by satisfaction, and that this satisfaction was shaped by factors such as benefit, information quality, verification, service and system quality, ease of use, and cognitive load. The findings indicate that user satisfaction plays a central role in sustainable e-learning use. Moore et al. (2011) examined how learning environments are defined among 43 individuals. Their findings revealed inconsistencies in the terms used for different delivery formats and showed that concepts such as "distance education," "e-learning," and "online learning" lead to different expectations and perceptions. Lee (2010) proposed a theoretical model that combines the expectation-confirmation model, the TAM, and the theory of planned behavior (TPB) to explain and predict e-learning users' intention to continue. The results showed that satisfaction had the strongest effect on users' intention to continue, and it was followed by perceived benefit, attitude, concentration, subjective norm, and perceived behavioral control. In summary, the findings from these studies synthesize numerous research studies conducted in the context of educational technologies and e-learning on learning design, user satisfaction, acceptance models, and the effects of VLEs. The findings from these studies reveal that student-centered instructional design, user satisfaction, and the pedagogical alignment of technological tools are important and critical for effective learning. Furthermore, despite the potential of innovative technologies such as AR and VR, it is emphasized that the alignment of design-learning theory is often overlooked by researchers and practitioners.

Regarding the role of digital technologies, Jensen and Konradsen (2017) provided a detailed review of head-mounted displays (HMDs) in education and highlight situations where they are helpful for skill development, particularly in cognitive and psychomotor domains. However, they also warn about potential issues with HMDs, such as cybersickness and distractions, suggesting that traditional methods might produce better results in some cases (Jensen & Konradsen, 2017). Similarly, Scherer et al. (2019) sought to explain factors influencing how educators adopt digital technologies, identifying key aspects that either support or hinder the integration of technology in educational practice using the TAM. Particularly, the study by Jensen and Konradsen (2017) collectively supports the idea that technology's role in education goes beyond just transferring content and that it should focus on creating enriching learning experiences that enhance skills in education. Akçayır and Akçayır (2017) conducted a systematic review of 68 articles on the use of AR in education. They found an increase in the number of AR studies after 2013 and reported that the most frequently reported advantage was improved learning success. Domínguez et al. (2013) developed a gamification plugin for a popular e-learning platform in a university course and found that students in the gamified group performed better on practical assignments and overall grades but showed lower performance on written assignments and participated less in classroom activities. A study by Sung et al. (2016) conducted a meta-analysis and research synthesis of the effects of mobile devices on teaching and learning based on the 110 experimental and quasi-experimental articles published between 1993 and 2013. The overall effect of mobile device use on education was found to be moderate, with an average effect size of 0.523. In addition,

Strayer (2012) compared the learning environments of inverted and traditional statistics courses at a university. The findings show that although students in the inverted classroom were initially less satisfied with the course structure, over time, they became more open to collaborative learning and innovative teaching methods.

Concerning the impact of the COVID-19 pandemic on the use of ET in instruction. For example, Pokhrel and Chhetri (2021) summarize a wide range of responses to the pandemic, pointing out disruptions to traditional learning practices and the challenges faced during the reopening of educational institutions, and provide a comprehensive report on the impact of the COVID-19 pandemic on online teaching and learning from various papers. They recommend online education as a good alternative for instruction during the pandemic (Pokhrel & Chhetri, 2021). At the same time, Mishra et al. (2020) emphasize the importance of using existing resources and digital technologies to promote effective online teaching and learning strategies during the pandemic. Their comprehensive analysis revealed and discussed both quantitative and qualitative perspectives on educators' and students' experiences during this transition (Mishra et al., 2020). Similarly, Bao (2020) outlines five highly effective teaching principles for the effective implementation of large-scale online education. These principles include suitability for students' readiness levels, effective transfer of teaching information, provision of adequate support, increasing quality participation, and the need to prepare in advance for possible problems. She indicated these principles are necessary to enhance the success of online education by considering instructional content, student interaction, and technical infrastructure. Overall, the studies reviewed emphasize the importance of results regarding the use of ET in instruction for instructional aims. Studies by Bao (2020) and Mishra et al. (2020) highlight that adaptability, relevance, and adequate support are crucial during transitions to online education to overcome disruptions during the COVID-19 pandemic. Furthermore, Crawford et al. (2020) examined various countries' pedagogical responses to the pandemic and underscored that the rapid conversion to online formats and digital pedagogies necessitated a reevaluation of existing teaching methodologies and the implementation of new strategies to ensure educational continuity. They aimed to examine policies during the pandemic and indicated that there is a recognition that students can be supported digitally without compromising academic quality and standards of the curriculum. All these findings from the studies we reviewed above underscore a growing recognition of the importance of innovative, flexible educational strategies tailored to both in-person and online formats.

Emerging Themes From Keyword Co-Occurrence Analysis

To analyze the keywords included in the publications by authors in their articles, we used VOSviewer. For this aim, we included only the keywords with a minimum of 5 co-occurrences, so that the results yielded 32 keywords that met the threshold. **Figure 3**: Co-occurrence relations among keywords. Cluster analysis results in keyword co-occurrence analysis revealed four clusters.

Cluster 1—Technology-Supported Student-Centered Instruction and Learners' Acceptance Levels

Cluster 1 (red color in **Figure 3**) included keywords, including AR, collaborative learning, education computing, ET, engineering education, research, students, teaching, technology, technology acceptance, and VR. These keywords co-occur frequently in this cluster. These keywords indicate that there is a research area that is technology-supported and student-centered and investigates students and teachers and their acceptance levels. It looks like this research trend appears prominently in research on ET in the literature because researchers focus on the use of technological tools (especially AR, VR and computers) in teaching and learning processes, and the acceptance levels of teachers and students in the integration of technologies into education constitute a critical theme in terms of the use of technology. Moreover, the co-occurring keywords suggest that a certain amount of research has explored the effects of technological tools (especially AR, VR, and computers) on learners in the teaching and learning processes and the acceptance levels of teachers and students. In addition, in this cluster, VR emerged as a keyword in education technology. This result suggests researchers' efforts to understand and examine the effects of technology-enhanced student-centered instruction.

Cluster 2—Monitoring, Modeling, and Development of Learning Processes in Digital Learning Environments

Cluster 2 (green color in **Figure 3**) includes e-learning, learning analytics, learning systems, distance education, computer-aided instruction, mathematical models, self-regulated learning, and survey keywords. The co-occurrence of these keywords refers to the monitoring, modeling, and development of learning processes in digital learning environments. This research cluster encompasses subtopics such as monitoring student learning behavior on e-learning platforms, collecting data through learning analytics, improving achievement through computer-assisted instruction, and supporting student self-regulation skills. Quantitative data collection about learning processes is also a part of this research topic. As can be understood from the emerging keywords in this cluster, researchers have explored e-learning and learners' learning processes in terms of monitoring, modeling, and development of learning processes.

These studies include learners' acceptance of e-learning (Bhuasiri et al., 2011; Lee et al., 2009; Selim, 2005), examination of learners' variables regarding e-learning using the TAM model (Cheung & Vogel, 2012; Lee, 2010; Park & Choi, 2009; Roca et al., 2006), students' expectations of, and experiences in e-learning (Paechter et al., 2010), learners' satisfaction about e-learning (Liaw, 2007; Sun et al., 2008; Wu et al., 2010), challenges and factors influencing the E-learning system usage during the COVID-19 pandemic (Almaiah et al., 2020), effectiveness of e-learning (Liaw, 2007), examining instructor and learner attitudes toward e-learning (Liaw et al., 2006), developing scale to measure learners' enjoyment of e-learning games (Fu et al., 2008), and personalized tutoring systems in e-learning (Klašnja-Milićević et al., 2010). The frequent occurrence of "e-learning" and its connection to "learning system" and "distance education" suggest the pressing need to examine the effects of e-learning on learners' learning outcomes and their acceptance and satisfaction.

Cluster 3-Teaching/Learning Strategies and Assessment in Distance Learning

Cluster 3 (blue color in **Figure 3**) consists of co-occurring keywords including adult learning, distance education and telelearning, evaluation methodology, pedagogical issues, and teaching/learning strategies. This research area focuses on how learners learn in digital and distance learning environments, effective teaching methods, pedagogical planning issues, and the evaluation of educational practices. These keywords also represent studies on effective instructional design and assessment methods, particularly for learners in distance learning environments. In particular, most keywords in this cluster are considered to be related to effective instructional design and assessment methods, particularly for learners in distance learning environments. In this cluster, researchers tended to apply SEM to explore the effects of situational interest, computer self-efficacy, and self-regulation: their impact on student engagement in distance education (Sun & Rueda, 2012), factors influencing adult learners' decision to drop out or persist in online learning (Park & Choi, 2009), and instructors' definitions of distance learning environments (Moore et al., 2011). Additionally, "adult learning" co-occurred frequently with other keywords in this cluster. For example, the study of Park and Choi (2009) examined factors influencing adult learners' decisions to drop out or persist in online learning.

Cluster 4—Online and Blended Learning Models and Applications in Higher Education During and After the Pandemic

Cluster 4 (yellow color in **Figure 3**) included blended learning, COVID-19, higher education, online education, and online learning keywords. The terms used in this research area focus on how distance and online learning processes, particularly those necessitated by the COVID-19 pandemic, are planned, implemented, transformed, and made sustainable in higher education institutions. These keywords also highlight how blended learning models were adopted in the post-pandemic era.

These emerging trends collectively suggest a gradual shift in ET research from foundational acceptance and usability concerns toward more process-oriented and context-specific investigations, particularly following the COVID-19 pandemic. This trajectory aligns with recent bibliometric findings indicating that ET research has increasingly prioritized adaptive, learner-centered, and hybrid instructional models (Mohsen et al., 2025), signaling a broader transformation in how technology is conceptualized and implemented in educational settings. It should also be noted that citation counts, while useful for identifying influential publications, do not necessarily reflect the methodological rigor or overall quality of a study. High citation

Table 7. Ranked list of the ten most frequently co-cited documents

Authors	Title	Focus	N	Journal	PT
Compeau and Higgins (1995)	Computer self-efficacy: Development of a measure and initial test	Individuals' self-efficacy in using computers	6	MIS Quarterly	Article
Davis (1989)	Perceived usefulness, perceived ease of use, and user acceptance of information technology	Technology acceptance	6	MIS Quarterly	Article
Venkatesh and Davis (2000)	A theoretical extension of the technology acceptance model: Four longitudinal field studies	TAM	5	Management Science	Article
Palloff et al. (1999)	Building learning communities in cyberspace: Effective strategies for the online classroom	Effective teaching strategies in online learning	4	-	Book
Hartley and Bendixen (2001)	Educational research in the Internet age: Examining the role of individual characteristics	The role of individual characteristics on the Internet	4	Educational Researcher	Article
Davis et al. (1992)	Extrinsic and intrinsic motivation to use computers in the workplace	The role of Internal and external motivation in computer use	4	Journal of Applied Social Psychology	Article
Venkatesh et al. (2003)	User acceptance of information technology: Toward a unified view	Development of a unified model (UTAUT) for technology acceptance	4	MIS Quarterly	Article
Taylor and Todd (1995)	Understanding information technology usage: A test of competing models	Comparing models that explain the use of information technologies	4	Information Systems Research	Article
Webster and Hackley (1997)	Teaching effectiveness in technology-mediated distance learning	Teaching effectiveness in distance education	4	Academy of Management Journal	Article
Davis et al. (1989)	User acceptance of computer technology: A comparison of two theoretical models	Comparing two different models for technology acceptance	4	Management Science	Article

Note. N: Number of co-citations & PT: Publication type

frequency may instead be shaped by factors such as publication age, journal visibility, open-access status, and disciplinary citation norms (Lai, 2020). Therefore, the findings of this study should be interpreted as indicators of research impact and visibility rather than direct measures of research quality.

Co-Citation Analysis

Table 7 lists the top 10 documents that were revealed in our results. The highly co-cited documents span the period from 1989 to 2003. Of the top 10 documents, three were published in 2020 by Davis (1989), Davis et al. (1989), and Davis et al. (1992). Other co-cited documents were published before the year 2003.

Documents on Individual Characteristics

The most co-cited article by Compeau and Higgins (1995) reported that individuals' self-efficacy and outcome expectations were found to be positively influenced by the encouragement of others in their work group, as well as others' use of computers. The study of Hartley and Bendixen (2001) pointed out that students' characteristics (such as self-regulation skills and epistemological beliefs) have a significant impact on success in Internet and other computer-based learning environments. According to them, these individual characteristics determine the extent to which students benefit from such learning environments. Students with high self-regulation skills are more successful in organizing information, setting goals, and monitoring understanding in web-based learning environments. Students with low self-regulation skills are more prone to failure in these flexible environments. Additionally, they have noted that individual beliefs about the nature of knowledge (e.g., the belief that knowledge is fixed, absolute, or simple) directly influence students' learning strategies and success. They have also pointed out that individual differences among students, such as motivation, self-efficacy, physical barriers, and learning disabilities, can affect access to learning opportunities and success. Furthermore, Palloff and Pratt (1999) published a book on developing well-planned and effective

computer-mediated distance learning. Webster and Hackley (1997) examined teaching effectiveness in distance learning. They reported 247 students' reactions to distance learning.

The results of these studies indicate that individual characteristics—such as self-efficacy, self-regulation, epistemological beliefs, and motivation—can significantly impact success in technology-supported learning and technology use. Research suggests that social support and the experiences of other users positively shape technology trust and expectations. Furthermore, for distance and web-based learning to be effective, both individual readiness and educational delivery must be planned and interactive.

Documents on TAM and the Unified Theory of Acceptance and Use of Technology

Six highly cited documents explored the uses of the TAM and the unified theory of acceptance and use of technology (UTAUT) models for the use of ET. For example, Davis (1989) indicated that perceived usefulness exhibited a substantial correlation with both self-reported current usage and self-predicted future usage. Venkatesh and Davis (2000) developed and tested a theoretical extension of the TAM that explains perceived usefulness and usage intentions. The extended model was strongly supported by all four organizations at all three points of measurement, accounting for 40%-60% of the variance in usefulness perceptions and 34%-52% of the variance in usage intentions. Both social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability, and perceived ease of use) significantly influenced user acceptance. Davis et al. (1992) reported a correlation of 0.63 between intentions and system utilization, with usefulness and enjoyment affecting usage behavior only through their impact on intentions. A favorable interaction between utility and enjoyment was identified. Venkatesh et al. (2003) reviewed user acceptance literature and concluded that UTAUT thus provides a useful tool for managers needing to assess the likelihood of success for new technology introductions and helps them understand the drivers of acceptance to proactively design interventions. Taylor and Todd (1995) evaluated the utilization of information technology and determined that the decomposed TPB provided a more comprehensive insight into behavioral intention by emphasizing the factors likely to affect system usage through the application of design and implementation strategies. Davis et al. (1989) found that perceived usefulness strongly influenced people's intentions, explaining more than half of the variance in intentions at the end of 14 weeks. Perceived ease of use had a small but significant effect on intentions as well, although this effect subsided over time. Attitudes only partially mediated the effects of these beliefs on intentions.

The results of all studies show that perceived usefulness is the strongest determinant of individuals' acceptance of new technologies, and that ease of use plays a supporting but secondary role in this effect. According to these studies, usage intention is formed through factors such as both usefulness and enjoyment and directly predicts system usage. In addition, individual and environmental factors such as social influences, cognitive evaluations, and behavioral beliefs make important contributions to the development of TAMs (**Figure 4**).

DISCUSSION

Research Trends

In this research, we examined the top 100 most cited articles on ET in the literature published from 2005 to 2024. First, our results revealed that most articles were published in 2010. In terms of total citation frequency, the results showed that articles that have the highest total number of citations were published in 2020, more than publications published in 2010. Results regarding country analysis indicated that the most cited articles were produced by researchers who had an affiliation in the USA and received the most citations. Taiwan and Australia represent the second and third places, respectively. In addition, in terms of the number of publications and citations, the UK, Australia, and Spain have the highest "citation/article" ratio compared to other countries.

Results concerning the authors who published the most cited articles on ET were Shane Dawson in the first rank. In the second rank, the most published author was Charles R. Graham, who came from Brigham Young University. In the third place, Andrew P. Ciganek, Hangjung Zo, Dragan Gasevic, Shu-Sheng Liaw, Jo

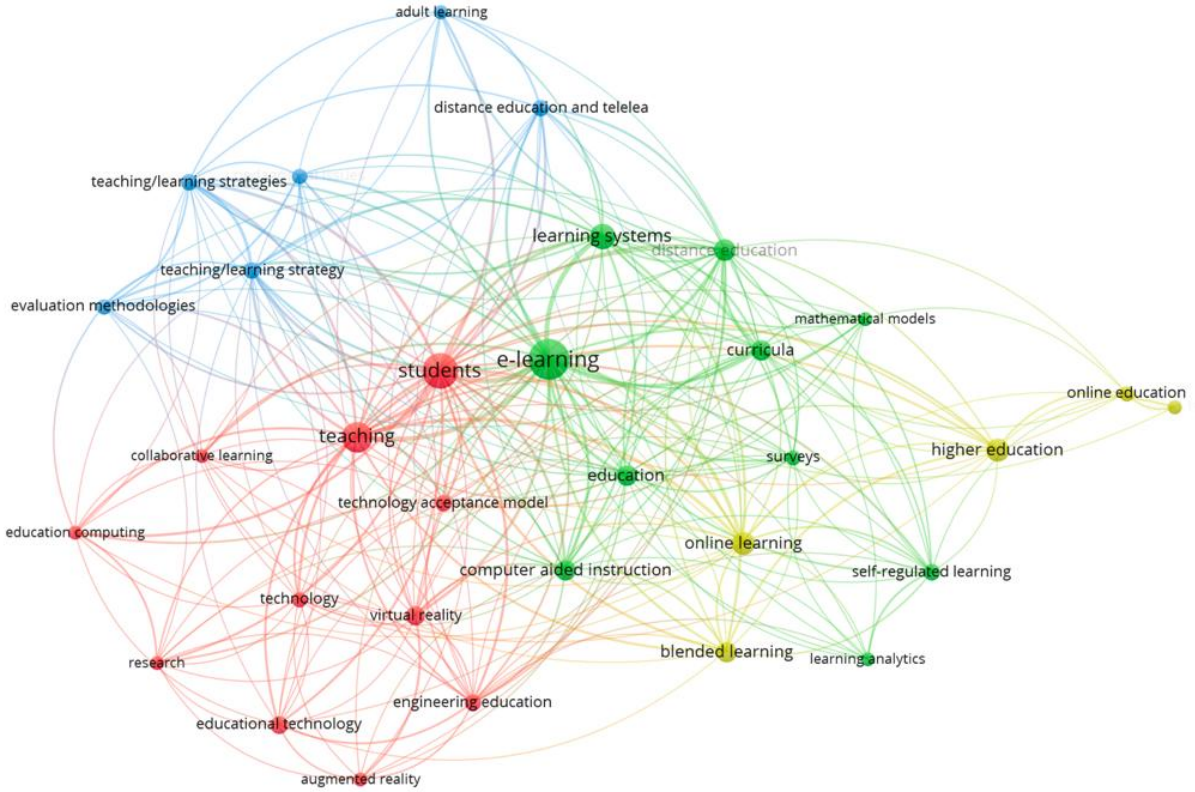

Figure 4. Visualization of the co-occurrence network analysis for the 100 most-cited articles on ET (created by the authors using VOSviewer software version 1.6.20)

Tondeur, Punya Mishra, and Gwo-Jen Hwang were authors. These researchers were from the USA, Taiwan, Australia, Belgium, South Korea, England, and China.

Our results regarding the journals with the highest number of publications among most cited articles revealed that Computers and Education was in the first rank with 46 articles. This journal is followed by Internet and Higher Education with 9 articles, Educational Technology & Society and British Journal of Educational Technology with 3 articles, and International Review of Research in Open and Distance Learning, Educational Research Review, Education and Information Technologies, Journal of Computing in Higher Education, Journal of Educational Computing Research, and CBE Life Sciences Education with 2 articles. The other 26 journals had one article in the top-cited 100 articles on ET. This result confirms similar results revealed by Kuzu and Kuzu (2022), who conducted a bibliometric study on educational games. They found that articles on educational games in Computers and Education and the British Journal of Educational Technology journals were the most cited articles. The reason for these results may stem from the fact that these journals have published quality empirical research on ET. The results are also similar to those of Darmawansah (2021), who found that the Australasian Journal of Educational Technology and the Computers and Education journal were the leading publication sources among the most-cited studies based on co-citation analysis. This result is also related to a finding from the literature that the Computer and Education journal has a big increase in citations, which is the most important measure of academic influence and reputation over time (Chen et al., 2019).

In addition, our results regarding the top 20 most-cited articles revealed three themes. The first key theme is the design and effectiveness of interactive multimodal learning environments. The second theme was related to the role of digital technologies, while the third was on the impact of the COVID-19 pandemic on the use of ET in instruction.

Ultimately, our findings from the keyword co-occurrence analysis identified four research clusters. The four emerging research trends identified through keyword co-occurrence analysis revealed that cluster 1 concentrated on technology-supported student-centered instruction and learners' acceptance levels, whereas cluster 2 investigated the monitoring, modeling, and development of learning processes within digital learning

environments. Cluster 3 concentrated on instructional techniques and evaluation methods in distance education, while cluster 4 investigated research pertaining to online and blended learning models and their implementation in higher education during and subsequent to the COVID-19 epidemic. Concerning these emerging research themes, our results are very parallel to those of Mahdavinasab and Haseli (2025), who found nine subject areas in their study on publications published in the Education and Information Technologies Journal from 1996 to 2023. Their analyses revealed nine themes, including the role of ICT and technology in education, blended learning and teacher training, e-learning and mobile learning, engaging and motivating learning environments, educational data mining and machine learning, distance education in different academic settings, education during the COVID-19 pandemic, ET in higher education, and the use of social media in education.

The results regarding the increase in publications during and after the COVID-19 epidemic are very similar to those of prior studies. Regarding reasons for this result, the pandemic forced educators, schools, and institutions to make a quick switch to online learning (Görgülü, 2025). This situation led to a rise in interest in research on ET. For this effort, educational institutions worldwide were compelled to adopt online platforms, and there was a significant increase in research investigating the effects of educational technologies on learners' achievement and learning outcomes and their challenges. In terms of this necessity, positive contributions of digital technologies after the pandemic have made them an intrinsic part of educational practice. Moreover, because of the pandemic's urgency, teachers and researchers had to look into not only how well existing technologies work, but also how to come up with new ways to get students involved from a distance. For example, V. Chen et al. (2022) pointed out that online learning tools were growing much faster than teachers had expected. Thus, e-learning methods were becoming more popular even after the pandemic. Even though after the pandemic, research trends in ET emerged during the pandemic, leading teachers and educators to use and benefit from the pedagogical benefits of various digital tools and platforms to enhance learning efficiency and engagement (Cheng et al., 2021).

Co-Citation Analysis

According to the results of the co-citation analysis, we found two main lines of research. The first main line focused on the individual characteristics of learners in their use of technology. Most of these articles are related to individual characteristics and show that individual characteristics such as self-efficacy, self-regulation, epistemological beliefs, and motivation can significantly influence success in technology-enhanced learning and technology use. One possible explanation for this result is that individual traits and variables such as efficiency, self-regulation, and epistemological beliefs have affected learners' use of technology. Therefore, researchers have identified the influence of these variables on technology use. For example, Scherer et al. (2019) reported individual characteristics such as self-efficacy and previous experiences with using the data of individual characteristics.

The second main line of research investigated the application of the TAM and UTAUT models to the use of ET. The results of all studies show that perceived usefulness is the strongest determinant of individuals' acceptance of new technologies and that ease of use plays a supporting but minor role in this effect. According to these studies, intention to use is formed by factors such as usefulness and enjoyment and directly predicts the use of the system. In addition, individual and environmental factors such as social influences, cognitive evaluations, and behavioral beliefs make an important contribution to the development of TAMs. The selection of these models for ET research stems from the fact that these models have provided researchers with insights into the factors that influence technology adoption. The TAM originally proposed by Davis (1989) assumes that perceived usefulness and perceived ease of use significantly influence a user's intention to adopt a technology. Following its introduction, Venkatesh and Davis (2000) extended the original TAM, emphasizing the role of social influence and cognitive instrumental processes in shaping users' perceptions and intentions over time and in different contexts of use. As previous research has shown that the UTAUT model provides a comprehensive framework that can explain greater variance in behavioral intentions and technology, the researchers chose to use it in their publication. In addition, the UTAUT model is also useful to study and understand the success of new technology development in terms of user adoption. For these reasons, both TAM and UTAUT have been widely adopted as a guide for ET research in theory and practice due to their proven reliability in different technologies and cultural contexts. Recent applications of the UTAUT

model, such as its extension with service quality dimensions to assess learning management system acceptance among pre-service teachers (Korsah et al., 2026), further demonstrate the model's continued relevance across diverse ET contexts.

Recommendations

The results of this research show that the number of citations for papers published in 2020 has risen sharply, likely due to the global shift to online learning during the COVID-19 pandemic. In light of this finding, we suggest that researchers should continue to explore the challenges and opportunities for post-pandemic education in both hybrid and online environments. In light of this finding, we suggest that there is a greater need for evidence on the implementation of ET applications in underrepresented or undeveloped Western contexts. In addition, the four emerging research trends can help curriculum developers ensure that learning outcomes are aligned with evidence-based strategies. For teachers and trainers, we suggest that a focus on technology-enhanced, student-centered teaching and the use of digital tools for process monitoring and modeling can help student learning and flexibility. The fact that TAM and UTAUT models are often cited together in other work suggests that they provide a strong theoretical basis for examining learner acceptance and engagement. Finally, our findings on the use of TAM and UTAUT models indicate that these models need to continue to be used for new technologies such as AI, VR, and learning analytics.

CONCLUSION

This bibliometric analysis provides research trends among the 100 most-cited articles on ET published between 2005 and 2024. The articles in this research were the most cited by researchers. This study provides results of a bibliometric analysis of the 100 most cited studies in ET from 2005 to 2024, sourced from the Scopus database and analyzed using bibliometric techniques. The results show that most articles were published around 2010, while the articles with the highest total citations were published in 2020. The country analysis revealed that the most cited articles were authored by researchers from the USA, Taiwan, and Australia. The results in terms of authors showed contributions from Australia, the USA, South Korea, Taiwan, and Belgium. In addition, the journal "Computers and Education" ranked first in terms of the number of publications among the 100 most cited articles. Ultimately, the analyses revealed four emerging research trends: cluster 1 focused on technology-enhanced, student-centered teaching and learner acceptance; cluster 2 examined the monitoring, modelling, and development of learning processes within digital environments; cluster 3 focused on teaching techniques and evaluation methods in distance learning; and cluster 4 examined online and blended learning models and their implementation in higher education during and after the COVID-19 pandemic. Finally, the results of analyzing the co-citations revealed that the researchers mainly co-cited documents that focused on the individual characteristics of learners in the use of technology and used the TAM/UTAUT models in their research. In summary, this paper provides detailed analyses of the historical development and research trends of the most-cited articles on ET and provides certain perspectives for future research for scholars.

Limitations

This study has several limitations that should be acknowledged. First, focusing on the top 100 most-cited articles, while a common convention in bibliometric research, means that citation counts are influenced by factors such as publication age, journal visibility, open-access status, and self-citation practices rather than purely reflecting research quality. Second, the study relied exclusively on the Scopus database; articles indexed only in other databases, such as Web of Science or ERIC, were not captured, which may limit the generalizability of the findings. Third, because the analysis was restricted to English-language journal articles, relevant conference papers, book chapters, and non-English publications on ET were excluded. Future research could address these limitations by triangulating multiple citation databases, including non-English sources, and complementing citation-based analysis with qualitative measures of research quality and impact.

Author contributions: OVV & TS: conceptualization, validation, writing – review & editing; **NAZ:** formal analysis, methodology; **YVC:** formal analysis; **MSP:** investigation, writing – original draft; **ZMS & AVS:** validation, 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: All data in this article are based on the SCOPUS database, and the information presented is drawn from the cited sources. This study was conducted in accordance with academic ethics and the principles of the Declaration of Helsinki and does not involve any unethical behavior, such as plagiarism, fabrication, or falsification.

AI statement: The authors declare that they used Grammarly and QuillBot to improve the grammar and readability of the manuscript. After using these tools, the authors carefully reviewed and edited the manuscript as necessary and took full responsibility for the content of the published article.

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.

REFERENCES

Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review, 20*, 1-11. https://doi.org/10.1016/j.edurev.2016.11.002

Ali, N. (2024). An investigation into the impact of educational technology on the teaching-learning process in higher education. *International Research Journal of Innovations in Engineering and Technology, 8*(5), 142-149. https://doi.org/10.47001/irjiet/2024.805022

Almaiah, M. A., Al-Khasawneh, A., & Althunibat, A. (2020). Exploring the critical challenges and factors influencing the e-learning system usage during COVID-19 pandemic. *Education and Information Technologies, 25*(6), 5261-5280. https://doi.org/10.1007/s10639-020-10219-y

Balaji, D., & Sahija, D. (2022). Effectiveness of ICT in enhancing learning procedure in higher education. *TTAICTE, 1*(2), 22-30. https://doi.org/10.36647/ttaicte/01.02.a004

Bao, W. (2020). COVID-19 and online teaching in higher education: A case study of Peking University. *Human Behavior and Emerging Technologies, 2*(2), 113-115. https://doi.org/10.1002/hbe2.191

Bhuasiri, W., Xaymoungkhoun, O., Zo, H., Rho, J. J., & Ciganek, A. P. (2011). Critical success factors for e-learning in developing countries: A comparative analysis between ICT experts and faculty. *Computers & Education, 58*(2), 843-855. https://doi.org/10.1016/j.compedu.2011.10.010

Chen, C. C., Wang, N. C., Tang, K. Y., & Tu, Y. F. (2022). Research issues of the top 100 cited articles on information literacy in higher education published from 2011 to 2020: A systematic review and co-citation network analysis. *Australasian Journal of Educational Technology, 38*(6), 34-52. https://doi.org/10.14742/ajet.7695

Chen, H., Sun, D., Yang, Y., Looi, C., & Jia, F. (2023). Detecting and visualizing research trends of blended learning: A bibliometric analysis of studies from 2013-2022. *Eurasia Journal of Mathematics Science and Technology Education, 19*(10), Article em2336. https://doi.org/10.29333/ejmste/13592

Chen, V., Sandford, A., LaGrone, M., Charbonneau, K., Kong, J., & Ragavaloo, S. (2022). An exploration of instructors' and students' perspectives on remote delivery of courses during the COVID-19 pandemic. *British Journal of Educational Technology, 53*(3), 512-533. https://doi.org/10.1111/bjet.13205

Chen, X., Yu, G., Cheng, G., & Hao, T. (2019). Research topics, author profiles, and collaboration networks in the top-ranked journal on educational technology over the past 40 years: A bibliometric analysis. *Journal of Computers in Education, 6*(4), 563-585. https://doi.org/10.1007/s40692-019-00149-1

Cheng, Y., Huang, C., & Hsu, L. C. (2021). Research trends in educational technology. *International Journal of Technology and Human Interaction, 18*(1), 1-14. https://doi.org/10.4018/ijthi.293191

Cheung, R., & Vogel, D. (2012). Predicting user acceptance of collaborative technologies: An extension of the technology acceptance model for e-learning. *Computers & Education, 63*, 160-175. https://doi.org/10.1016/j.compedu.2012.12.003

Compeau, D. R., & Higgins, C. A. (1995). Computer self-efficacy: Development of a measure and initial test. *MIS Quarterly, 19*(2), 189-211. https://doi.org/10.2307/249688

Crawford, J., Butler-Henderson, K., Rudolph, J., Malkawi, B., Glowatz, M., Burton, R., Magni, P. A., & Lam, S. (2020). COVID-19: 20 countries' higher education intra-period digital pedagogy responses. *Journal of Applied Learning & Teaching, 3*(1), 9-28. https://doi.org/10.37074/jalt.2020.3.1.7

Dalgarno, B., & Lee, M. J. W. (2009). What are the learning affordances of 3-D virtual environments? *British Journal of Educational Technology, 41*(1), 10-32. https://doi.org/10.1111/j.1467-8535.2009.01038.x

Darmawansah, D. (2021). A Bibliometric Mapping of educational technology in Indonesia (2011-2020). *Indonesian Scholars Scientific Summit Taiwan Proceeding, 3*, 8-15. https://doi.org/10.52162/3.2021107

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

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

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Social Psychology, 22*(14), 1111-1132. https://doi.org/10.1111/j.1559-1816.1992.tb00945.x

Domínguez, A., Saenz-De-Navarrete, J., De-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & Education, 63*, 380-392. https://doi.org/10.1016/j.compedu.2012.12.020

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education, 59*(2), 423-435. https://doi.org/10.1016/j.compedu.2012.02.001

Fu, F., Su, R., & Yu, S. (2008). EGameFlow: A scale to measure learners' enjoyment of e-learning games. *Computers & Education, 52*(1), 101-112. https://doi.org/10.1016/j.compedu.2008.07.004

Görgülü, D. (2025). Higher education in Türkiye in the shadow of chaos: A study on students from the faculty of education in times of crisis. *Educational Point, 2*(1), Article e119. https://doi.org/10.71176/edup/16452

Hartley, K., & Bendixen, L. D. (2001). Educational research in the Internet age: Examining the role of individual characteristics. *Educational Researcher, 30*(9), 22-26. https://doi.org/10.3102/0013189X030009022

Hossein-Mohand, H., Hossein-Mohand, H., Albanese, V., & Del Carmen Olmos Gómez, M. (2025). AI in mathematics education: A bibliometric analysis of global trends and collaborations (2020-2024). *Eurasia Journal of Mathematics Science and Technology Education, 21*(2), Article em2576. https://doi.org/10.29333/ejmste/15915

Ishmuradova, I. I., Chistyakov, A. A., Chudnovskiy, A. D., Grib, E. V., Kondrashev, S. V., & Zhdanov, S. P. (2024). A cross-database bibliometrics analysis of blended learning in higher education: Trends and capabilities. *Contemporary Educational Technology, 16*(2), Article ep508. https://doi.org/10.30935/cedtech/14478

Jensen, L., & Konradsen, F. (2017). A review of the use of virtual reality head-mounted displays in education and training. *Education and Information Technologies, 23*(4), 1515-1529. https://doi.org/10.1007/s10639-017-9676-0

Jiménez, C. R., Prieto, M. S., & García, S. A. (2019). Technology and higher education: A bibliometric analysis. *Education Sciences, 9*(3), Article 169. https://doi.org/10.3390/educsci9030169

Kilavuz, F. (2024). Exploring research trends in the implementation of the flipped classroom model in educational research: A review of literature. *Pedagogical Research, 9*(3), Article em0216. https://doi.org/10.29333/pr/14730

Klašnja-Milićević, A., Vesin, B., Ivanović, M., & Budimac, Z. (2010). E-learning personalization based on hybrid recommendation strategy and learning style identification. *Computers & Education, 56*(3), 885-899. https://doi.org/10.1016/j.compedu.2010.11.001

Korsah, D. P., Wireko-Ampem, J. K., & Forson, I. (2026). Extending the UTAUT model with service quality to assess Moodle LMS acceptance in Ghanaian colleges of education. *Interdisciplinary Educational Technology, 2*(1), Article e107. https://doi.org/10.71176/interedtech/17900

Kuzu, Y., & Kuzu, O. (2022). Eğitsel oyunlar ie ilgili yapılan çalışmaların bibliyometrik bir analizi [A bibliometric analysis of studies on educational games]. *Ahi Evran Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 8*(3), 724-740. https://doi.org/10.31592/aeusbed.1102403

Lai, C. L. (2020). Trends of mobile learning: A review of the top 100 highly cited papers. *British Journal of Educational Technology, 51*(3), 721-742. https://doi.org/10.1111/bjet.12884

Lee, B., Yoon, J., & Lee, I. (2009). Learners' acceptance of e-learning in South Korea: Theories and results. *Computers & Education, 53*(4), 1320-1329. https://doi.org/10.1016/j.compedu.2009.06.014

Lee, M. (2010). Explaining and predicting users' continuance intention toward e-learning: An extension of the expectation-confirmation model. *Computers & Education, 54*(2), 506-516. https://doi.org/10.1016/j.compedu.2009.09.002

Liaw, S. (2007). Investigating students' perceived satisfaction, behavioral intention, and effectiveness of e-learning: A case study of the Blackboard system. *Computers & Education, 51*(2), 864-873. https://doi.org/10.1016/j.compedu.2007.09.005

Liaw, S., Huang, H., & Chen, G. (2006). Surveying instructor and learner attitudes toward e-learning. *Computers & Education, 49*(4), 1066-1080. https://doi.org/10.1016/j.compedu.2006.01.001

Liesa-Orús, M., Latorre-Cosculluela, C., Vázquez-Toledo, S., & Sierra-Sánchez, V. (2020). The technological challenge facing higher education professors: Perceptions of ICT tools for developing 21st century skills. *Sustainability, 12*(13), Article 5339. https://doi.org/10.3390/su12135339

Mahdavinasab, Y., & Haseli, D. (2025). Conceptual structure and trend topics of the education and information technologies journal: A bibliometrics analysis. *International Journal of Information Science and Management, 23*(1), 211-230.

Masveta, D. (2026). Using EdTech to reach the unreached: Innovative approaches to non-formal education in Zimbabwe. *Educational Point, 3*(1), Article e162. https://doi.org/10.71176/edup/18866

Mena-Guacas, A. F., Rodríguez, J. A. U., Trujillo, D. M. S., Gómez-Galán, J., & López-Meneses, E. (2023). Collaborative learning and skill development for educational growth of artificial intelligence: A systematic review. *Contemporary Educational Technology, 15*(3), Article ep428. https://doi.org/10.30935/cedtech/13123

Mishra, L., Gupta, T., & Shree, A. (2020). Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. *International Journal of Educational Research Open, 1*, Article 100012. https://doi.org/10.1016/j.ijedro.2020.100012

Mohsen, M., Althebi, S., Bensalem, E., & Alsherif, N. (2025). A decade of highly cited articles in educational technology research: Emerging trends, dominant themes, and future directions. *Journal of Computing in Higher Education, 38*, 310-337. https://doi.org/10.1007/s12528-025-09435-7

Moore, J. L., Dickson-Deane, C., & Galyen, K. (2011). e-Learning, online learning, and distance learning environments: Are they the same? *The Internet and Higher Education, 14*(2), 129-135. https://doi.org/10.1016/j.iheduc.2010.10.001

Moreno, R., & Mayer, R. (2007). Interactive multimodal learning environments. *Educational Psychology Review, 19*(3), 309-326. https://doi.org/10.1007/s10648-007-9047-2

Olszewski, B., & Crompton, H. (2020). Educational technology conditions to support the development of digital age skills. *Computers & Education, 150*, Article 103849. https://doi.org/10.1016/j.compedu.2020.103849

Özel, M. (2024). An analysis of research trends on socio-scientific issues in science education over two decades from 2004 to 2023. *Journal of Mathematics Science and Technology Education, 1*(1), 69-83. https://doi.org/10.12973/jmste.1.1.69

Paechter, M., Maier, B., & Macher, D. (2010). Students' expectations of, and experiences in e-learning: Their relation to learning achievements and course satisfaction. *Computers & Education, 54*(1), 222-229. https://doi.org/10.1016/j.compedu.2009.08.005

Palloff, R. M., & Pratt, K. (1999). *Building learning communities in cyberspace: Effective strategies for the online classroom*. Jossey-Bass Publishers.

Park, J.-H., & Choi, H. J. (2009). Factors influencing adult learners' decision to drop out or persist in online learning. *Educational Technology & Society, 12*(4), 207-217.

Pokhrel, S., & Chhetri, R. (2021). A literature review on impact of COVID-19 pandemic on teaching and learning. *Higher Education for the Future, 8*(1), 133-141. https://doi.org/10.1177/2347631120983481

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education, 147*, Article 103778. https://doi.org/10.1016/j.compedu.2019.103778

Roca, J. C., Chiu, C., & Martínez, F. J. (2006). Understanding e-learning continuance intention: An extension of the technology acceptance model. *International Journal of Human-Computer Studies, 64*(8), 683-696. https://doi.org/10.1016/j.ijhcs.2006.01.003

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education, 128*, 13-35. https://doi.org/10.1016/j.compedu.2018.09.009

Selim, H. M. (2005). Critical success factors for e-learning acceptance: Confirmatory factor models. *Computers & Education, 49*(2), 396-413. https://doi.org/10.1016/j.compedu.2005.09.004

Strayer, J. F. (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research, 15*(2), 171-193. https://doi.org/10.1007/s10984-012-9108-4

Sun, J. C., & Rueda, R. (2012). Situational interest, computer self-efficacy and self-regulation: Their impact on student engagement in distance education. *British Journal of Educational Technology, 43*(2), 191-204. https://doi.org/10.1111/j.1467-8535.2010.01157.x

Sun, P., Tsai, R. J., Finger, G., Chen, Y., & Yeh, D. (2008). What drives a successful e-learning? An empirical investigation of the critical factors influencing learner satisfaction. *Computers & Education, 50*(4), 1183-1202. https://doi.org/10.1016/j.compedu.2006.11.007

Sung, Y., Chang, K., & Liu, T. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education, 94*, 252-275. https://doi.org/10.1016/j.compedu.2015.11.008

Taylor, S., & Todd, P. A. (1995). Understanding information technology usage: A test of competing models. *Information Systems Research, 6*(2), 144-176. https://doi.org/10.1287/isre.6.2.144

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

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

Webster, J., & Hackley, P. (1997). Teaching effectiveness in technology-mediated distance learning. *Academy of Management Journal, 40*(6), 1282-1309. https://doi.org/10.5465/257034

Wu, H., Lee, S. W., Chang, H., & Liang, J. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education, 62*, 41-49. https://doi.org/10.1016/j.compedu.2012.10.024

Wu, J., Tennyson, R. D., & Hsia, T. (2010). A study of student satisfaction in a blended e-learning system environment. *Computers & Education, 55*(1), 155-164. https://doi.org/10.1016/j.compedu.2009.12.012