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The Trend of e-Learning Research: A Bibliometric Analysis

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ABSTRACT

E-learning has become a central component of higher education. However, the rapid expansion of research across artificial intelligence (AI), machine learning, analytics, gamification, and digital learning has produced a fragmented knowledge landscape. Existing bibliometric studies remain limited in scope, database coverage, disciplinary focus, or sample size, creating a need for a more comprehensive assessment of recent publication patterns, influential contributors, emerging themes, and neglected areas in e-learning research. This study addresses this gap through a bibliometric analysis of 2,000 Scopus-indexed documents from 2023–2026, including early-access records assigned to 2026. Bibliographic data were cleaned and harmonised using OpenRefine and biblioMagika®, while performance indicators and author-keyword co-occurrence networks were analysed using biblioMagika® and VOSviewer. The dataset comprised 7,694 contributing authors, 940 cited publications, and 5,165 citations, with an h-index of 27. India, Indonesia, and China were the most productive countries, while notable disparities emerged between publication volume and citation influence across authors, institutions, and sources. Keyword co-occurrence analysis identified five interconnected thematic clusters centred on learning experience and technology acceptance, advanced technologies quality, artificial intelligence infrastructure, and assessment, engagement, computational analysis, and pedagogical and training contexts. AI, machine learning, adaptive learning, gamification, and learning analytics represent prominent contemporary research fronts. However, foundational instructional design approaches, particularly the ADDIE model, remain comparatively peripheral to the dominant technology-oriented network. The study therefore reveals a technology pedagogy imbalance in contemporary e-learning scholarship. It provides an evidence-based paper for researchers and higher education institutions seeking to align technological innovation with stronger pedagogical and instructional-design foundations.

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1. INTRODUCTION

The implementation of e-learning has gained significant attention from both scholars and practitioners due to the rapid growth of information technology applications in society. E-learning, also known as electronic learning, refers to asynchronous or synchronous learning experiences delivered through technological platforms and internet connections (Singh & Thurman, 2019; Omanyo & Ndiege, 2024). E-learning is a crucial element in higher education institutions (HEIs) because it facilitates learner-centric education, student networking, and inclusive learning (Pretorius et al., 2021). Notably, e-learning serves as a strategic digital platform for HEIs, focusing not only on technology adoption but also on innovative educational strategies that offer learners access to a vast repository of knowledge.

Scholarly discussion on e-learning research has grown significantly. Varekar (2021) proposed that e-learning serves as a collaborative platform that enables learners to develop their technical skills and actively engage in the learning process. Scholars such as Ukpabio (2019) and Sarbaini et al. (2024) also highlight e-learning's role in fostering learning engagement across cultural dimensions, developing digital skills, and advancing innovative teaching and delivery methods. Furthermore, Shahzad et al. (2024) underscore e-learning as a key method for competency development that is transforming learning approaches globally. Thus, e-learning is consistently promoted as an online platform that combines digital material delivery with educational services, yielding substantial benefits for HEIs.

While research on e-learning is active, a comprehensive exploration of overarching research trends and knowledge gaps remains necessary. Only a few scholars have conducted bibliometric analyses on e-learning, and existing studies exhibit notable limitations. For example, Yuki et al. (2025) and Shahzad et al. (2024) relied exclusively on the Web of Science (WOS) database, limiting their scope and depth of analysis. Similarly, Tibaná-Herrera et al. (2018) used SCOPUS and SCImago Journal & Country Rank data but analysed a limited sample of only 219 publications. Meanwhile, Oluwadele et al. (2023) focused specifically on e-learning in medical education from 1976 to 2022, missing the field's broader interdisciplinary scope.

To address these gaps, this study conducts a comprehensive bibliometric analysis of e-learning literature using the Scopus database to ensure extensive coverage. It also offers a holistic view of multidisciplinary keyword themes and global scholarly contributions. This research contributes insights into key authors, influential publication sources, emerging themes, and critical knowledge gaps. Consequently, this study provides a robust foundation and valuable reference for future research by both academicians and practitioners. This study therefore addresses the following research questions:

RQ.1 What is the current landscape of e-learning publications?
RQ.2 What are the main disparities in research output and impact among authors, institutions and countries?
RQ.3 What source titles have been most influential in shaping the e-learning research field?
RQ.4 What are the key keyword themes and emerging research areas in e-learning?

2. LITERATURE REVIEW

2.1 The Conceptualisation of e-Learning

E-learning is commonly understood as a technology-mediated mode of teaching and learning in which instructional content, interaction, assessment, and learning activities are delivered, in whole or in part, through digital platforms. In the literature reviewed in this study, the concept extends beyond simply moving classroom materials online. Singh and Thurman (2019), for example, demonstrate that online learning encompasses different configurations of synchronous and asynchronous interaction, indicating that e-learning should be conceptualised as a flexible learning arrangement rather than a single technological format. Similarly, Omanyo and Ndiege (2024) position e-learning as a technology-enabled educational approach that can support the sustainability and accessibility of higher education. Together, these perspectives suggest that e-learning incorporates technological infrastructure, pedagogical processes, learner interaction, and institutional arrangements.

This broader conceptualisation matters because the educational significance of e-learning does not lie solely in its technological delivery mechanisms. In higher education, digital platforms can support learner-centred instruction, extend access to learning resources, facilitate interaction among students and instructors, and enable learning beyond conventional spatial and temporal boundaries (Pretorius et al., 2021). Varekar (2021) further emphasises the collaborative dimension of e-learning, particularly its potential to strengthen learners' technological capabilities while encouraging active participation in learning processes. From this perspective, e-learning constitutes both a delivery environment and an educational ecosystem through which learners interact with content, technologies, instructors, and peers. Existing literature consequently supports an understanding of e-learning as a multidimensional phenomenon that combines digital infrastructure with pedagogical, behavioural, and social processes.

The conceptual development of e-learning has also increasingly reflected questions regarding educational quality and learner experience. Digital technologies can facilitate personalised content, practical guidance, and interaction between learners and instructors while creating opportunities for more flexible instructional arrangements (Hwang, 2014; Jia et al., 2022). These functions have helped position e-learning as an important component of contemporary higher education rather than merely an alternative used when face-to-face instruction is unavailable. Diamond and Irwin (2013), for instance, show how e-learning may support student-centred learning, whereas Nikolić et al. (2019) situate e-learning within the broader use of information and communication technologies in teaching. Lau et al. (2018) further demonstrate that the effectiveness of digital learning environments remains closely connected to the organisation and use of learning resources. Accordingly, developing e-learning involves continuous interaction between technological capability and the design of meaningful learning experiences.

The dynamics of e-learning have gained widespread attention among scholars and practitioners as a technology platform capable of enhancing class engagement and knowledge acquisition. As Diamond and Irwin (2013) note, e-learning supports a learning environment and develops students' cognitive skills. Similarly, Nikolic et al. (2019) and Lau et al. (2018) agreed that e-learning is an educational modality delivered through electronic means, using information and communication technology. Furthermore, e-learning involves accessing and understanding instructional materials through digital platforms. Overall, this research highlights the diverse study of e-learning, its adaptation to diverse learning styles and its capacity to promote engagement and motivation.

3. METHODS

3.1 Research Design

This paper adopted a bibliometric and science-mapping design to examine recent developments, scholarly influence, and the conceptual structure of e-learning research. Bibliometric analysis is appropriate when the research objective extends beyond synthesising individual findings to quantitatively characterising a body of literature in terms of productivity, citation impact, contributing actors, and intellectual relationships. Performance analysis therefore complemented science mapping. The former evaluates publication and citation patterns, while the latter identifies relationships among concepts and the field's thematic organisation. This combination aligns with established bibliometric guidelines, which distinguish performance indicators from relational techniques used to reveal the intellectual structure of a research domain (Donthu et al., 2021; Zupic & Čater, 2015).

The combined design is particularly suitable for the present study because the research questions address four analytically distinct dimensions of e-learning scholarship: (1) the publication landscape, (2) disparities in productivity and influence among authors, institutions, and countries, (3) influential publication outlets and highly cited documents, (4) and the thematic structure and emerging research fronts of the field. Bibliometric analysis provides quantitative evidence for the first three dimensions, whereas science mapping enables the examination of relationships among author keywords rather than treating them simply as independent frequency counts. Furthermore, contemporary methodological guidelines stress that substantive research questions should drive bibliometric studies and that researchers should explicitly document database selection, search profiles, data-cleaning procedures, analytical parameters, and cluster interpretation (Ellegaard, 2026).

3.2 Search Strategy and Data Retrieval

Bibliographic records were retrieved from the Scopus database on 12 August 2025. The study covered documents assigned publication years from 2023 to 2026, with the 2026 records representing publications already indexed at the time of extraction. The final analytical dataset comprised 2,000 documents. These parameters define the dataset analysed in this study.

Scopus was selected as the sole bibliographic source because it provides broad multidisciplinary coverage along with structured bibliographic, affiliation, keyword, and citation metadata suitable for bibliometric performance analysis and network construction. While Scopus and Web of Science are both established databases for bibliometric research, their coverage differs; database selection can therefore affect document retrieval and citation-based indicators. Comparative studies have demonstrated substantial differences in journal coverage between the two databases across disciplines, countries, and languages (Mongeon & Paul-Hus, 2016). Nevertheless, Scopus offers extensive journal coverage across disciplinary fields and is widely recognised alongside Web of Science as a primary bibliographic source for bibliometric applications (Pranckutė, 2021).

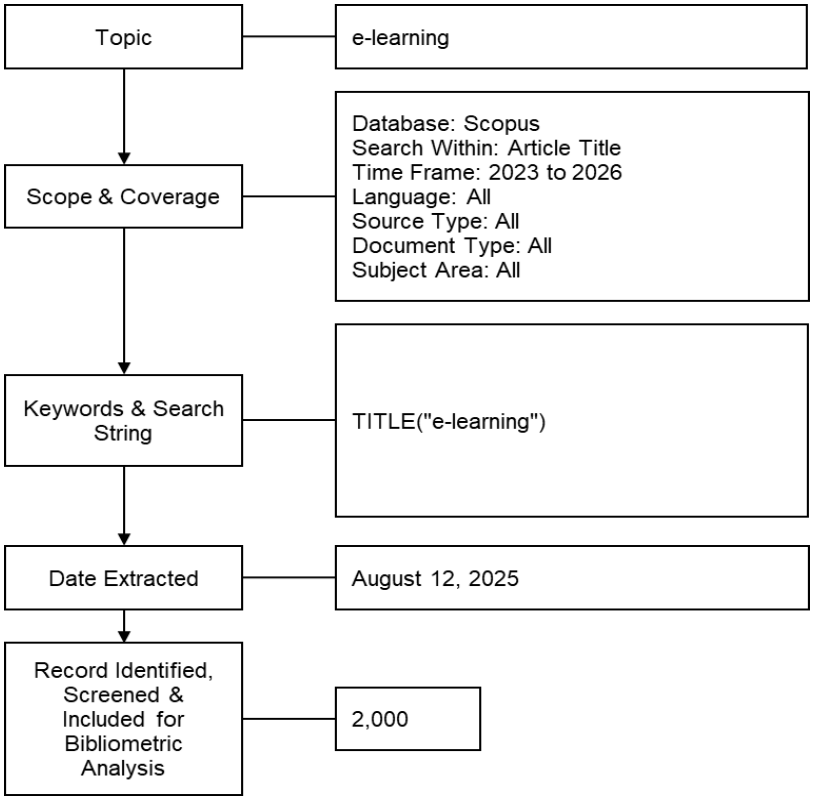


Figure 1 *Flow diagram of the search strategy*
Source: Zakaria et al. (2021) & Moher et al. (2009)

3.3 Data Cleaning and Harmonisation

The final bibliographic records were exported from Scopus as a CSV file containing the metadata required for descriptive performance analysis and science mapping. Data preparation preceded all substantive analyses as bibliometric datasets commonly contain inconsistencies in author names, institutional affiliations, country designations, spelling, punctuation, capitalisation, and author keywords. Failing to address these inconsistencies can artificially divide conceptually identical entities into separate nodes, thereby distorting frequencies, link strengths, cluster membership, and network interpretation.

OpenRefine was used primarily to clean and harmonise textual bibliographic fields, particularly author keywords. Variants differing only in capitalisation, punctuation, hyphenation, grammatical number (singular or plural), or spelling were inspected and standardised when they clearly represented the same concept. For example, variants such as "e-learning," "E-Learning," and equivalent formatting variants were harmonised rather than treated as distinct analytical terms. OpenRefine provides faceting, clustering, transformation, and multi-value manipulation procedures suited to preparing bibliographic data for subsequent analysis. Ahmi (2023) demonstrates its application to Scopus-derived bibliographic records, emphasising that unresolved textual inconsistencies can undermine the accuracy and validity of bibliometric findings.

biblioMagika® was used as an additional data-preparation and performance-analysis environment. During this cleaning stage, biblioMagika facilitated system inspection and standardisation of author names, institutional affiliations, and country information before transferring records to subsequent analytical tools. Particular attention was given to institutional-name variants as affiliations frequently appear under abbreviated, translated, faculty-level, campus-level, or legacy institutional titles. Harmonising clearly equivalent institutional names reduced the risk that a single organisation would be represented as multiple entities.

These data-cleaning procedures were not intended to recode the intellectual content of the publications substantively. Rather, consolidation was limited to cases where variants could reasonably be treated as equivalent. Conceptually distinct terms were retained as separate entries. This distinction matters because excessive merging can erase meaningful conceptual differences, whereas insufficient cleaning can create artificial fragmentation. Data harmonisation was therefore treated as a fundamental validity-control stage rather than merely a cosmetic pre-processing step. Current methodological literature emphasises that bibliometric studies should disclose cleaning and reduction procedures as these decisions can influence the configuration of resulting networks and clusters (Ellegaard, 2026).

3.4 Performance Analysis

Performance analysis used biblioMagika® to characterise the corpus's productivity and citation structure. The indicators examined included total publications (TP), number of contributing authors (NCA), number of cited publications (NCP), total citations (TC), citations per publication (C/P), citations per cited publication (C/CP), authors per publication, citations per year, h-index, g-index, m-index, and citation totals within the h-core, alongside productivity and citation indicators for individual authors, institutions, countries, and source titles. These measures were used descriptively, not as direct measures of research quality. Publication counts indicate scholarly productivity, while citation measures approximate scholarly visibility or influence within the selected database and citation window. The h-index and related measures integrate both productivity and citation information but remain dependent on dataset composition and time. Consequently, no single indicator was interpreted as sufficient evidence of academic quality.

In addition, VOSviewer was used to construct and visualise author-keyword co-occurrence networks. Co-word analysis assumes that terms co-occurring across documents reflect conceptual relatedness; aggregating these co-occurrence relationships enables the identification and visualisation of major thematic clusters within the research. VOSviewer is particularly suited to this task because it combines bibliometric network construction, similarity-based spatial mapping, clustering, and interactive visualisation in a single analytical environment (van Eck & Waltman, 2010).

The analysis employed author keywords as the unit of analysis and full counting as the counting method. Under full counting, each qualifying occurrence or co-occurrence contributes its full weight to the network. This approach was selected to represent the observed prominence and connectivity of keyword relationships in the dataset without fractionalising their contribution based on the number of keywords associated with individual records. The distinction between full and fractional counting is consequential because different counting rules can produce different network weights and structures. Consequently, report the chosen counting method explicitly rather than treating it as a software default (Perianes-Rodriguez et al., 2016).

4. RESULTS

4.1 Document Profile

The first research question examined the current state of e-learning publications. This subsection examines the distribution of publication attributes, including document type, source type, language, subject areas, and trends, based on the aggregate number of publications and citations. The citation metrics for the e-learning publication landscape were analysed to assess their relevance and impact. The bibliometric profile presented in Table 1 provides useful insights into e-learning publication patterns, author contributions, and overall impact. The dataset includes 2,000 papers and reflects significant collaboration among 7,694 contributing authors, with a total of 5,165 citations (indicating a moderate level of citation).

Table 1 *Main Information*

Main Information	Data
Publication Years	2023 - 2026
Total Publications	2000
Citable Year	3
Number of Contributing Authors	7694
Number of Cited Papers	940
Total Citations	5,165
Citation per Paper	2.58
Citation per Cited Paper	5.49
Citation per Year	1721.67
Citation per Author	0.67
Author per Paper	3.85
Citation sum within h-Corea	2,040
h-indexb	27
g-indexc	45
m-indexd	9.000

Note(s): ah-Core: A set of core articles used in the calculation of the h-index. These are the most impactful articles that collectively account for an author's or journal's h-index, highlighting key contributions to the field; bh-index: A widely used bibliometric metric that measures both productivity and citation impact. An h-index of h indicates that an author has h papers with at least h citations each; cg-index: A metric designed to improve on the h-index by giving more weight to highly cited articles. It is calculated so that the top g articles collectively receive at least g^2 citations, emphasising the distribution of citations across the data set; dm-index: A metric that adjusts the h-index by considering the length of an author's publishing career. It is calculated as m = h/t, where h is the h-index and t is the number of years since the author's first publication. This index accounts for the time-dependent aspect of an author's impact.
Source(s): Generated by the author(s) using biblioMagika® (Ahmi, 2024)

The involvement of 7,694 contributing authors across 2,000 publications, equivalent to approximately 3.85 authors per paper, suggests that recent e-learning research is predominantly collaborative rather than individually produced. This collaborative structure aligns with the field's increasingly interdisciplinary character, where educational research intersects with artificial intelligence, information and communication technologies, learning analytics, behavioural research, and digital-system development. Such interdisciplinarity is evident in recent e-learning scholarship addressing intelligent learning systems, adaptive technologies, technology acceptance, gamification, and AI-supported learning environments (Gligorea et al., 2023; Jia et al., 2022; Khaldi et al., 2023; Liu & Yu, 2023). Accordingly, the authorship profile is better interpreted as evidence that the research domain draws expertise from multiple disciplinary and technical perspectives, rather than merely as a measure of publication volume.

The citation structure, however, suggests that scholarly visibility is unevenly distributed across the dataset. Fewer than half of the publications had received at least one citation at the time of data extraction, while the mean citation rate across the entire corpus remained modest. The higher average observed when considering only cited publications indicates that citation influence is concentrated within a subset of the literature rather than distributed uniformly across all documents. This concentration should not be interpreted as evidence that uncited or lightly cited publications lack scholarly value. The dataset covers a relatively recent period, and publications appearing toward the end of the observation window have had substantially less time to accumulate citations. This temporal limitation is especially relevant to research areas undergoing rapid technological development, where recent studies on AI-supported and adaptive e-learning may not yet have reached their longer-term citation potential. Therefore, citation indicators in this study primarily capture early scholarly visibility within a short citation window rather than mature or definitive intellectual influence.

The h-index of 27 and g-index of 45 provide additional evidence that the corpus contains a distinguishable group of comparatively influential publications. The h-index indicates that a core set of publications has achieved a minimum level of sustained citation recognition. In contrast, the higher g-index reflects the presence of particularly highly cited contributions that exert disproportionate influence on the citation structure. The concentration of 2,040 citations within the h-core reinforces this interpretation. Rather than suggesting uniformly high impact across the field, these measures point to a stratified knowledge structure in which a limited number of publications have acquired substantial visibility. At the same time, a much larger proportion remains infrequently cited. This pattern is consistent with the prominence of recent research fronts identified in the literature, particularly studies associated with artificial intelligence, machine learning, personalised learning, gamification, and intelligent e-learning systems (Gligorea et al., 2023; Halkiopoulos & Gkintoni, 2024; Khaldi et al., 2023; Liu & Yu, 2023).

Interpret the reported m-index with caution because the corpus covers only about three citable years. A relatively high m-index in a short observation period can be strongly affected by the compressed publication window and should therefore not be treated as evidence that e-learning research possesses unusually high long-term citation performance. The same caution applies to the annual citation average, which the limited dataset duration mathematically influences. For a rapidly developing research domain, these time-normalised indicators are useful descriptively but are less suitable for evaluating sustained intellectual maturity.

Taken together, the bibliometric profile depicts e-learning as an active, collaborative, and increasingly interdisciplinary research domain, but one whose recent citation structure remains concentrated around a comparatively small influential core. The combination of substantial publication activity, extensive authorship participation, and uneven citation accumulation supports the need to move beyond aggregate productivity indicators. Identifying which authors, institutions, countries, source titles, and conceptual themes drive this concentration of influence is therefore necessary to understand how the recent intellectual structure of e-learning research is developing. Subsequent analyses consequently examine the distribution of productivity and citation impact across these units and map the thematic relationships that underpin the field.

4.2 Publication Trend

To answer the first research question, this study outlines developments in e-learning research from 2023 to 2026. The e-learning research topics are growing quickly, with 1,122 total publications and 2,597 total citations. Figure 2 shows a positive relationship between publications and citations, especially as the number increases. Both publications and citations increased sharply from 2023 to 2024. However, in 2025, the overall number of publications and citations

dropped by about 565 and 272, respectively. In the years that followed, both measures fell sharply, although the reduction in citations seems to have been more sudden than the loss in publications. The citation line graph is smoother and shows a pattern that lags slightly but follows a similar trend to publications. This suggests that publications directly affect citations, and that most citations occur at or shortly after the peak in publications.

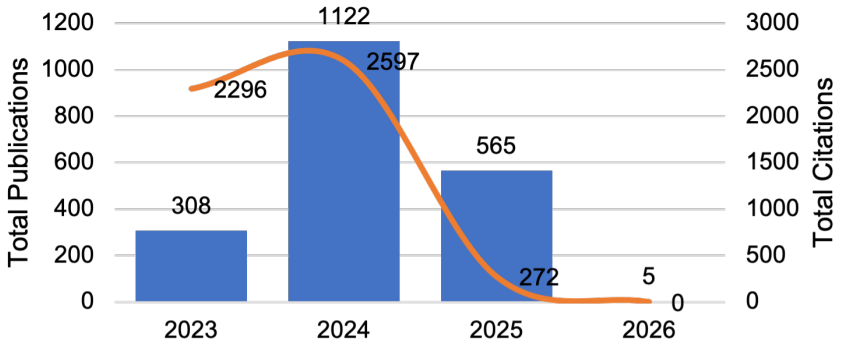


Figure 2. *Total publications and citations per year*
Source: Generated by the author(s) using biblioMagika (Ahmi, 2024)

The annual distribution of publications and citations suggests a period of rapid concentration in e-learning scholarship rather than stable longitudinal growth. As Figure 2 shows, publication activity increased substantially from 2023 to 2024, with 2024 as the dataset's dominant year. This concentration aligns with a period when e-learning research moved beyond basic online learning adoption toward more technologically sophisticated applications. Recent scholarship increasingly connects e-learning with artificial intelligence, adaptive learning, machine learning, gamification, and intelligent learning systems (Gligorea et al., 2023; Khaldi et al., 2023; Liu & Yu, 2023). The observed publication expansion may therefore reflect not simply greater interest in e-learning as a delivery mode, but an intellectual broadening of the field as emerging technologies became integrated into established questions of learning design, engagement, personalisation, and educational effectiveness.

The expansion also needs to be understood in relation to the changing role of digital learning within higher education. Earlier work associated with the COVID-19 period documented substantial shifts toward online learning and highlighted behavioural and institutional adaptation to digital education (Lin et al., 2021; Wang et al., 2021). More recent studies have extended this agenda by examining increasingly intelligent and adaptive forms of e-learning, including AI-supported personalisation and adaptive assessment (Gligorea et al., 2023; Halkiopoulos & Gkintoni, 2024). The strong publication concentration in 2024 can therefore be interpreted cautiously as part of a transition from research focused primarily on the adoption and continuity of online learning to research investigating how advanced digital technologies can enhance or restructure the learning experience. This interpretation frames the recent expansion as a potential thematic shift in the field rather than merely an increase in publication volume.

The apparent decline after 2024 should not, however, be interpreted as evidence that scholarly interest in e-learning is contracting. The Scopus dataset was extracted on 12 August 2025, meaning that the 2025 publication count represents an incomplete calendar year, while the small number of records assigned to 2026 reflects documents already indexed with a future publication year. Consequently, the downward pattern at the end of Figure 2 is primarily subject to database and observation-window effects. Treating it as a substantive decline would risk conflating incomplete indexing with changes in research activity. The appropriate interpretation is therefore that the dataset demonstrates strong publication activity up to 2024, while the trajectory for subsequent years remains indeterminate until complete annual records are available.

A similar qualification is necessary when interpreting the citation pattern. Citations are heavily conditioned by publication age, and papers published in 2023 and 2024 have had more opportunity to accumulate scholarly recognition than those indexed during 2025 or assigned to 2026. The low citation totals observed for the most recent publications therefore indicate limited citation exposure rather than weak research influence. Moreover, the co-movement between

publications and citations should not be interpreted as evidence that publication volume directly generates citation impact. Citation accumulation depends on the visibility, relevance, dissemination, and intellectual influence of contributions, and the present dataset already indicates that influence is concentrated within a subset of highly cited studies. For example, recent work on AI-enabled adaptive learning, gamification, and intelligent e-learning systems has attracted substantial scholarly attention, suggesting that citation visibility may be tied to emerging research fronts rather than publication quantity alone (Gligorea et al., 2023; Khaldi et al., 2023; Liu & Yu, 2023).

Conceptually, the annual pattern therefore points to a field experiencing rapid thematic reorientation rather than demonstrable decline. E-learning scholarship appears increasingly intertwined with AI-driven personalisation, computational approaches, gamified learning environments, and adaptive technologies, extending earlier concerns with technology acceptance and online-learning effectiveness (Jia et al., 2022; Wang et al., 2024). This implies that annual output alone cannot explain the field's intellectual development. Examining influential publications, institutional and geographical contributions, and particularly keyword co-occurrence structures is necessary to determine whether the recent concentration of research corresponds to the consolidation of established themes or the emergence of new technological research fronts.

4.3 Publication by Authors

To address the second research question, this paper examined the main disparities in research output and impact among authors, institutions and countries. First, the paper explores the contributions of prolific authors, focusing on at least six publications and metrics such as the number of papers, cited papers, average citations per year, average citations per cited paper, and h, g, and m-indexes. Table 2 provides a detailed overview of the most productive authors, with AN NA standing out as a notable example: 24 publications, but only 1 citation and 0.04 citations per paper and cited paper. The h- and g-indices are both 1, and the m-index is 0.333. Goosen, Leila, from the University of South Africa, has published 11 papers and gained 23 citations, which yields 2.09 citations per paper. Their research mostly focuses on applying e-learning as a teaching strategy and on teachers' adoption of e-learning, especially in the open education context.

Table 2 *Most Influential Authors*

Full Name	Current Affiliation	Country	TP	NCP	TC	C/P	C/CP	*h*	*g*	*m*
AN,NA	Affiliation NA	Country NA	24	1	1	0.04	1.00	1	1	0.333
Goosen, Leila	University of South Africa	South Africa	11	8	23	2.09	2.88	3	4	1.000
Tsarev, Roman	MIREA - Russian Technological University (RTU MIREA)	Russian Federation	9	4	13	1.44	3.25	3	3	1.500
Rey, William P.	Mapua University	Philippines	6	2	4	0.67	2.00	2	2	1.000
Hanirex, D. Kerana	Bharath Institute of Higher Education and Research	India	6	3	6	1.00	2.00	1	2	0.500
Ahamed, H. Riaz	Bharath Institute of Higher Education and Research	India	6	3	6	1.00	2.00	1	2	0.500
Wang, Shang	Beijing Polytechnic	China	6	4	13	2.17	3.25	3	3	1.000
Esponda-Pérez, Jorge Alb	Universidad de Ciencias y Artes de Chiapas	Mexico	6	2	4	0.67	2.00	1	2	0.500
Tirumanadham, N.S. Koti	Bharath Institute of Higher Education and Research	India	6	5	59	9.83	11.80	3	6	1.500
Thaiyalnayaki, S.	Bharath Institute of Higher Education and Research	India	6	5	59	9.83	11.80	3	6	1.500
Samonte, Mary Jane	Mapua University	Philippines	5	0	0	0.00	0.00	0	0	0.000
Hunter, Kathleen F.	University of Alberta	Canada	5	1	1	0.20	1.00	1	1	0.500
Butler, Jeffrey I.	University of Alberta	Canada	5	1	1	0.20	1.00	1	1	0.500
Chasteen, Alison L.	University of Toronto	Canada	5	1	1	0.20	1.00	1	1	0.500
Moody, Elaine	Dalhousie University	Canada	5	1	1	0.20	1.00	1	1	0.500
Dahlke, Sherry	University of Alberta	Canada	5	1	1	0.20	1.00	1	1	0.500
Fox, Mary T.	York University	Canada	5	1	1	0.20	1.00	1	1	0.500
Alamsyah, Doni Purnama	Bina Nusantara University	Indonesia	5	2	3	0.60	1.50	1	1	0.500
Jeghal, Adil	Sidi Mohamed Ben Abdellah University	Morocco	5	1	2	0.40	2.00	1	1	0.500
Madhavi, A.	VNR Vignana Jyothi Institute of Engineering and Technology	India	5	1	5	1.00	5.00	1	2	0.333
Waginc, Waginc	Universitas Negeri Padang	Indonesia	5	3	32	6.40	10.67	3	5	1.000
Shahzad, Khurram	Government College University Lahore	Pakistan	5	4	36	7.20	9.00	3	5	1.000
Shannaq, Boumedyen	University of Buraimi	Oman	5	2	7	1.40	3.50	2	2	1.000
Bachtiar, Fitra A.	Brawijaya University	Indonesia	4	1	1	0.25	1.00	1	1	0.333
Srivastava, Nidhi	Amity University	India	4	1	1	0.25	1.00	1	1	0.333

The author-level results reveal a marked separation between publication productivity and citation influence, indicating that visibility within recent e-learning scholarship is not determined by output volume alone. The most prolific entry in the dataset records substantially more publications than the other authors but attracts negligible citation recognition. As this entry is labelled "AN, NA" with missing affiliation and country information, it should not be interpreted as evidence of genuine scholarly leadership; rather, it points to a metadata quality limitation that warrants caution in author-level ranking. More substantively, authors such as Tirumanadham and Thaiyalnayaki achieve considerably stronger citation intensity despite contributing fewer publications, suggesting that a relatively small set of contributions can acquire disproportionate intellectual visibility.

The contrast between productivity and impact also indicates that the recent e-learning literature has not consolidated around a single dominant author or intellectual centre. Goosen and Tsarev demonstrate relatively sustained publication activity, whereas authors such as Tirumanadham, Thaiyalnayaki, Wagino, and Shahzad display stronger citation performance relative to their publication volume. This dispersion reflects the heterogeneous development of e-learning research, which increasingly spans technology adoption, intelligent learning systems, gamification, artificial intelligence, and learner-centred digital environments (Jia et al., 2022; Khaldi et al., 2023; Liu & Yu, 2023; Shahzad et al., 2024). Rather than reflecting a mature field dominated by a small number of canonical scholars, the pattern better fits a rapidly evolving research space in which influence is distributed across multiple specialised contributions.

A further feature is the geographical diversity of the more visible contributors. Authors affiliated with institutions in India, South Africa, the Russian Federation, Indonesia, Pakistan, China, the Philippines, Morocco, Oman, and Canada appear among the leading contributors. This distribution suggests that contemporary e-learning research is not organised exclusively around traditional North American or Western European centres of scholarship. The prominence of contributors from Asian and emerging higher-education systems is theoretically relevant because e-learning increasingly operates across heterogeneous institutional, technological, and socio-cultural environments. This internationalisation complements earlier literature emphasising that adoption and participation in digital learning are context-dependent, shaped by institutional conditions, learner behaviour, cultural factors, and the perceived utility of technological systems (Lin et al., 2021; Ukpabio, 2019; Wang et al., 2024).

The identical bibliometric profiles of several author pairs, particularly Tirumanadham and Thaiyalnayaki, also suggest that part of the observed influence may derive from recurrent co-authorship rather than independent scholarly trajectories. Consequently, author-level productivity tables should not be interpreted as a direct ranking of individual intellectual contribution. Without complementary co-authorship or collaboration-network analysis, it is difficult to determine whether highly cited outputs represent individually dispersed expertise or concentrated research teams. This distinction matters because bibliometric influence can arise from collaborative research programmes in which authors repeatedly share the same publication and citation record. The current findings therefore support interpreting author productivity together with institutional and network evidence rather than treating publication counts as autonomous indicators of leadership.

Taken together, the author analysis portrays recent e-learning scholarship as distributed, collaborative, and thematically plural, with no straightforward correspondence between productivity and scholarly impact. The field appears to reward contributions associated with emerging research priorities more strongly than sustained publication volume alone. This pattern aligns with the growing visibility of technologically intensive research streams, including AI-supported learning, intelligent systems, adaptive environments, and gamification, documented in recent e-learning literature (Gligorea et al., 2023; Halkiopoulos & Gkintoni, 2024; Khaldi et al., 2023; Liu & Yu, 2023). This suggests that the field's intellectual development is better understood through the interaction of citation influence, collaboration, institutional concentration, and thematic positioning than through author productivity rankings alone.

4.4 Publication by Institutions

Table 3 shows the most prolific institutions contributing to the field of e-learning, using a minimum threshold of ten publications. The University of South Africa emerged as the frontrunner among the most productive institutions, with 75 total publications, 168 total citations and an h-index of 6, reflecting both high publication volume and scholarly influence. Universitas Negeri Padang follows with 45 total publications and the highest h-index (h=10), underscoring its citation performance and research consistency. This shows that Indonesian institutions have a strong research foundation that actively contributes to shaping e-learning development. Mapua University ranks third with 44 total publications, albeit a low h-index of 2. Institutions such as Amity University in India also made notable contributions, achieving the highest total citation count (336 citations) and an average of 11.59 citations per paper, signalling exceptional research impact in shaping intellectual development.

Table 3 *Most Productive Institutions*

Most Productive Institutions

Institution Name	Country	TP	NCP	TC	C/P	C/CP	*h*	*g*	*m*
University of South Africa	South Africa	75	46	168	2.24	3.65	6	12	2.000
Universitas Negeri Padang	Indonesia	45	21	192	4.27	9.14	10	13	3.333
Mapua University	Philippines	44	8	12	0.27	1.50	2	3	1.000
Bina Nusantara University	Indonesia	42	12	46	1.10	3.83	6	6	3.000
The University of Jordan	Jordan	38	21	129	3.39	6.14	5	11	1.667
Sidi Mohamed Ben Abdellah University	Morocco	35	6	40	1.14	6.67	2	6	0.667
University of Windsor	Canada	34	34	39	1.15	1.15	1	6	0.500
Bharath Institute of Higher Education and Research	India	31	23	206	6.65	8.96	8	14	4.000
Amity University	India	29	10	336	11.59	33.60	4	18	1.333
Abdelmalek Essaadi University	Morocco	27	10	32	1.19	3.20	5	5	1.667
University of Alberta	Canada	27	5	8	0.30	1.60	1	2	0.500
King Faisal University	Saudi Arabia	27	8	21	0.78	2.63	3	4	1.000
Universitas Muhammadiyah Lampung	Indonesia	26	10	16	0.62	1.60	2	4	0.667
Affiliation NA	Country NA	24	1	1	0.04	1.00	1	1	0.333
Sri Lanka Institute of Information Technology	Sri Lanka	24	6	66	2.75	11.00	6	8	2.000
Tehran University of Medical Sciences	Iran	23	11	31	1.35	2.82	3	5	1.000
Vellore Institute of Technology	India	22	7	18	0.82	2.57	3	4	1.000
Universiti Utara Malaysia	Malaysia	22	15	78	3.55	5.20	5	8	1.667
Universiti Teknologi Malaysia	Malaysia	22	13	141	6.41	10.85	8	11	2.667
King Abdul Aziz University	Saudi Arabia	21	9	113	5.38	12.56	6	10	2.000
Shiraz University of Medical Sciences	Iran	20	9	39	1.95	4.33	5	6	2.500
Symbiosis International University	India	20	7	33	1.65	4.71	4	5	1.333
Prince Sattam Bin Abdulaziz University	Saudi Arabia	20	13	160	8.00	12.31	7	12	2.333
The University of Melbourne	Australia	20	4	10	0.50	2.50	1	3	0.333
National University	Philippines	19	0	0	0.00	0.00	0	0	0.000

The institutional distribution indicates that contemporary e-learning scholarship is characterised by a decentralised yet uneven research structure, in which publication productivity and citation influence do not necessarily coincide. While the University of South Africa records the highest publication volume, institutions such as Amity University, Universitas Negeri Padang, the Bharath Institute of Higher Education and Research, Universiti Teknologi Malaysia, and Prince Sattam Bin Abdulaziz University display comparatively stronger citation-based performance relative to their output. This divergence suggests that publication counts alone cannot adequately assess institutional prominence in e-learning. Some institutions appear to function as high-volume contributors, while others produce smaller bodies of work with higher citation concentration, reflecting different modes of participation in the field's development.

The geographic composition of the leading institutions is particularly revealing. Universities from South Africa, Indonesia, India, Jordan, Morocco, Saudi Arabia, Malaysia, Iran, Sri Lanka, the Philippines, Canada, and Australia are represented among the most productive contributors. The prominence of institutions from Asia, the Middle East, and other Non-Western settings extends the conventional view of digital-learning research as being concentrated primarily within established Western research systems. This pattern aligns with the broader expansion of e-learning

in response to heterogeneous educational, technological, and institutional conditions. Research on e-learning adoption and sustainability has similarly emphasised that digital learning develops within context-specific infrastructures, learner environments, and institutional constraints rather than through a uniform global pathway (Lin et al., 2021; Omanyo & Ndiege, 2024; Pretorius et al., 2021). The institutional results therefore add a geographical dimension to this literature by indicating that knowledge production itself is increasingly distributed across diverse higher-education systems.

Within this broader dispersion, the comparatively strong presence of Indonesian, Indian, Malaysian, and Saudi Arabian institutions suggests emerging regional research concentrations rather than a single globally dominant institutional centre. Such clustering may reflect the growing strategic importance of digitally mediated education in rapidly expanding higher-education systems. However, the current bibliometric data cannot establish institutional policy or investment as causal explanations. More cautiously, the pattern indicates that these regions have developed sufficient research capacity to contribute repeatedly and visibly to contemporary e-learning scholarship. This interpretation is consistent with the field's thematic expansion into intelligent systems, artificial intelligence, digital competency development, and adaptive learning, areas that increasingly require collaboration between educational and technology-oriented expertise (Jia et al., 2022; Liu & Yu, 2023; Shahzad et al., 2024).

The contrast between institutions with similar publication volumes but markedly different citation performance further suggests that thematic positioning and the visibility of contributions shape research influence rather than institutional output alone. For example, institutions producing fewer publications may nevertheless achieve stronger citation intensity when their research engages with rapidly developing themes or influential methodological approaches. This possibility is consistent with the manuscript's broader evidence that AI, machine learning, intelligent learning systems, gamification, and adaptive learning have become particularly visible research fronts (Gligorea et al., 2023; Halkiopoulos & Gkintoni, 2024; Khaldi et al., 2023). Nevertheless, citation intensity should not be equated directly with research quality, particularly given the short citation window of the 2023–2026 dataset. The institutional indicators are better interpreted as measures of early scholarly visibility and influence within the defined Scopus corpus.

The presence of an unidentified affiliation entry also reinforces the need for caution when interpreting institutional rankings. Bibliographic inconsistencies can fragment or misattribute institutional contributions, particularly when affiliation metadata are incomplete or inconsistently indexed. Consequently, institutional productivity tables should be interpreted as representations of the available bibliographic metadata rather than exact measures of organisational research capacity. This issue also justifies the manuscript's data-harmonisation procedures, because unresolved institutional variants may artificially divide outputs belonging to the same university.

Overall, the institutional landscape portrays e-learning as a geographically dispersed and institutionally plural research domain, with influence distributed across multiple higher-education systems and no clear correspondence between productivity and citation impact. This pattern extends prior e-learning literature by showing that the field's intellectual expansion is accompanied by diversification in its institutional centres of knowledge production. It also points to a potentially important future direction: examining whether the emerging regional concentrations are interconnected through international collaboration or remain relatively separate research communities. Such analysis would clarify whether the globalisation of e-learning scholarship is producing an integrated international knowledge network or a collection of regionally specialised institutional clusters.

4.5 Publication by Countries

Table 4 depicts a geographically uneven yet distinctly international structure of contemporary e-learning scholarship. India, Indonesia, and China lead publication activity, indicating that recent knowledge production in the field is strongly concentrated in Asia rather than dominated exclusively by North American or Western European research systems. This pattern aligns with the broader expansion of digitally mediated education across rapidly developing higher-education systems, where e-learning has become increasingly embedded in institutional teaching, technological innovation, and learner-support strategies. The prominence of Asian contributors also complements research emphasising the intersection of e-learning with artificial intelligence, intelligent systems, and digital competency development (Jia et al., 2022; Shahzad et al., 2024). Rather than a peripheral regional contribution, Asian scholarship is a major driver of the field's recent intellectual development.

Table 4 *Most Productive Countries*

Most Productive Countries

Country	TP	NCP	TC	C/P	C/CP	*h*	*g*	*m*
India	971	412	2533	2.61	6.15	24	50	8.000
Indonesia	634	288	872	1.38	3.03	11	29	3.667
China	458	252	1897	4.14	7.53	22	43	7.333
Germany	307	170	437	1.42	2.57	7	20	2.333
United States	299	141	485	1.62	3.44	10	22	3.333
Iran	286	149	637	2.23	4.28	9	25	3.000
Malaysia	256	140	625	2.44	4.46	14	25	4.667
Saudi Arabia	247	124	1091	4.42	8.80	19	33	6.333
Morocco	232	76	319	1.38	4.20	7	17	2.333
Canada	232	109	365	1.57	3.35	7	19	2.333
Jordan	204	131	663	3.25	5.06	12	25	4.000
United Kingdom	172	102	288	1.67	2.82	5	16	1.667
Philippines	162	41	74	0.46	1.80	3	8	1.000
Japan	153	69	211	1.38	3.06	4	14	1.333
South Africa	142	83	294	2.07	3.54	8	17	2.667
France	120	77	190	1.58	2.47	5	13	1.667
Australia	119	48	223	1.87	4.65	8	14	2.667
Spain	118	75	314	2.66	4.19	7	17	2.333
Italy	108	47	166	1.54	3.53	7	12	2.333
Netherlands	94	47	151	1.61	3.21	5	12	1.667
Russian Federation	91	47	298	3.27	6.34	10	17	3.333
Pakistan	89	61	437	4.91	7.16	13	20	4.333
Romania	86	34	2315	26.92	68.09	9	48	3.000
Turkey	84	42	187	2.23	4.45	10	13	3.333
Iraq	72	18	62	0.86	3.44	5	7	1.667

Publication volume, however, does not correspond uniformly to citation influence. China and Saudi Arabia achieve stronger citation performance relative to their publication output than several countries with comparable or greater productivity. At the same time, Pakistan displays comparatively high citation intensity despite a smaller publication base. This divergence suggests that national prominence should not be interpreted simply as a function of document count. Citation visibility may instead reflect the thematic positioning of national research portfolios, particularly when studies engage with rapidly expanding topics such as AI-supported learning, intelligent e-learning systems, adaptive learning, and technology-enabled educational innovation (Gligorea et al., 2023; Halkiopoulos & Gkintoni, 2024; Liu & Yu, 2023). The national findings therefore reinforce the broader conclusion that productivity and scholarly influence represent analytically distinct dimensions of research performance.

Romania constitutes the clearest outlier in this pattern. Despite producing substantially fewer documents than the leading countries, it records an exceptionally high total citation count and average citation rate. This profile is unlikely to indicate uniformly strong influence across the Romanian research portfolio; rather, it more plausibly reflects citation concentration in a small number of highly visible publications. The relatively moderate h-index compared with its extraordinarily high citation-per-publication value supports this cautious interpretation. Consequently, Romania should not be ranked directly above larger research systems based on average citation metrics alone. The pattern illustrates how country-level averages can be distorted by highly cited outliers and underscores why multiple indicators should be considered jointly when assessing national research influence.

The geographic distribution also reveals substantial participation from the Middle East, North Africa, Southeast Asia, and Sub-Saharan Africa. Saudi Arabia, Jordan, Morocco, Malaysia, Iran, and South Africa all maintain visible positions within the corpus. This dispersion aligns with the literature portraying e-learning as strongly conditioned by institutional infrastructure, access, sustainability, learner context, and regional educational circumstances (Omanyo & Ndiege, 2024; Pretorius et al., 2021). Furthermore, it extends earlier bibliometric work that established e-learning as an internationally distributed research domain rather than one confined to a narrow set of educational systems (Tibaná-Herrera et al., 2018). The present findings suggest that this internationalisation has become particularly pronounced in recent years, with knowledge production increasingly distributed across countries experiencing different technological capacities, educational structures, and developmental priorities.

At the same time, the country profile offers greater insight into national productivity than into international integration. High publication counts do not indicate whether countries collaborate extensively across borders or operate within relatively independent research streams. This distinction matters because the intellectual maturity of an international field depends not only on geographic diversity but also on how much national research communities exchange knowledge and co-produce scholarship. The broad geographical spread observed here therefore demonstrates substantial global participation but cannot, on its own, determine the degree of cross-national connectivity.

Overall, country-level publication evidence portrays contemporary e-learning scholarship as Asia-centred in volume, internationally dispersed in participation, and uneven in citation influence. This pattern extends prior literature by demonstrating that the recent technological evolution of e-learning is accompanied by a redistribution of research activity toward a wider set of national systems, particularly in Asia and the Middle East. Consequently, the field should no longer be interpreted solely through publication volume or through assumptions of Western intellectual dominance. Future science-mapping and collaboration analyses are needed to determine whether these geographically diverse contributions are converging around shared technological and pedagogical priorities or evolving into partially segmented regional research trajectories.

4.6 Publication by Source Titles

To answer the third research question, which seeks to identify the most influential source titles and highly cited articles shaping the landscape of e-learning research. Table 5 outlines the primary publication outlets in the domain. Specifically, Table 5 illustrates the distribution and scholarly impact of leading source titles within the e-learning field.

Table 5 *Most Productive Source Title*

Most Productive Source Title

Source Title	TP	NCA	NCP	TC	C/P	C/CP	*h*	*g*	*m*
Lecture Notes in Networks and Systems	76	297	12	25	0.33	2.08	3	4	1.500
AIP Conference Proceedings	56	214	12	20	0.36	1.67	2	3	0.667
Entertainment Computing	51	74	44	146	2.86	3.32	7	7	3.500
Education and Information Technologies	43	130	33	423	9.84	12.82	11	20	3.667
ACM International Conference Proceeding Series	39	103	11	26	0.67	2.36	3	3	1.000
BMC Medical Education	36	228	25	135	3.75	5.40	6	9	2.000
Sustainability (Switzerland)	21	68	17	128	6.10	7.53	6	11	2.000
Computer-Aided Design and Applications	20	28	4	4	0.20	1.00	1	1	0.500
Communications in Computer and Information Scienc	17	47	1	1	0.06	1.00	1	1	0.500
E-Learning and Digital Media	17	56	11	86	5.06	7.82	4	9	1.333
IEEE Access	15	72	12	73	4.87	6.08	6	8	3.000
Electronic Journal of e-Learning	14	51	8	38	2.71	4.75	3	6	1.000
Heliyon	14	47	12	114	8.14	9.50	6	10	2.000
Interactive Learning Environments	14	45	10	55	3.93	5.50	5	7	2.500
International Journal of Data and Network Science	14	68	11	74	5.29	6.73	4	8	1.333
International Journal of Information and Education Te	13	54	5	25	1.92	5.00	2	5	0.667
E3S Web of Conferences	12	38	4	9	0.75	2.25	2	2	0.667
Cogent Education	11	33	8	19	1.73	2.38	2	3	1.000
PLoS ONE	10	60	6	9	0.90	1.50	1	2	0.500
Studies in Systems, Decision and Control	10	36	4	23	2.30	5.75	3	4	1.500

Note: TP=total number of publications; NCA=number of contributing authors; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; g=g-index; m=m-index.

Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

The distribution of source titles suggests that contemporary e-learning scholarship is widely dispersed across publication outlets rather than consolidated within a small number of specialised journals. Although Lecture Notes in Networks and Systems records the highest publication volume, its citation performance is comparatively modest; similarly, AIP Conference Proceedings displays a similar pattern of high output alongside limited citation penetration. This divergence indicates that publication frequency and scholarly influence operate differently at the source level. Conference-oriented outlets appear to provide important dissemination channels for rapidly developing technological work, yet their higher publication throughput does not necessarily translate into equivalent citation visibility. For a field evolving alongside fast-moving digital technologies, such outlets may facilitate early communication of technical developments while journal articles provide a different pathway for sustained scholarly uptake.

A contrasting pattern is evident for Education and Information Technologies, which combines a relatively substantial publication base with the strongest citation and h-index performance among the leading sources. Its position is intellectually consistent with the increasing convergence between educational questions and technological innovation in e-learning research. Studies in this outlet include research on intelligent e-learning systems and predicting student performance using digitally generated learner data (Kukkar et al., 2023; Liu & Yu, 2023). Rather than representing e-learning solely as an educational-delivery mechanism, these contributions position it at the intersection of pedagogy, information technologies, machine learning, and learner analytics. The bibliometric prominence of this source therefore reinforces the field's broader shift toward technologically enriched, data-driven approaches to learning.

The source profile also reveals considerable disciplinary heterogeneity. Alongside education-focused journals, the leading outlets include sources associated with computing, engineering, medical education, sustainability, information systems, and interdisciplinary research. This dispersion is consistent with the conceptual evolution documented in the literature, where e-learning increasingly intersects with artificial intelligence and machine learning (Gligorea et al., 2023; Jia et al., 2022), intelligent educational systems (Liu & Yu, 2023), digital sustainability and technology-supported learning environments (Haque et al., 2024), and technology acceptance and continuance behaviour (Wang et al., 2024). The source structure therefore extends the view of e-learning as an interdisciplinary domain: technological development is not occurring separately from educational inquiry but is increasingly incorporated into the outlets through which e-learning knowledge is produced and circulated.

At the same time, several lower-volume journals exhibit comparatively strong citation intensity. Sustainability (Switzerland), Heliyon, E-Learning and Digital Media, and IEEE Access, for example, generate stronger citation performance relative to their publication counts than several higher-volume conference sources. Such differences should not be interpreted as direct evidence of journal quality, particularly because citation rates are sensitive to document type, field characteristics, publication timing, and individual highly cited papers. Nevertheless, they indicate that intellectual influence in recent e-learning research is not concentrated exclusively in outlets that publish the most papers. This distinction parallels the author, institutional, and country-level findings, where publication productivity and citation influence similarly diverge.

The relative prominence of outlets spanning education, computing, and interdisciplinary science also points to a field whose technological dimension is currently more consolidated than its pedagogical foundations. Research on intelligent systems, artificial intelligence, predictive analytics, and digitally mediated learning is distributed across several influential sources, whereas instructional design perspectives are less prominent among the dominant publication channels. This interpretation is consistent with the wider literature emphasising AI-supported adaptive learning (Gligorea et al., 2023; Halkiopoulos & Gkintoni, 2024), intelligent e-learning systems (Liu & Yu, 2023), and gamification (Khaldi et al., 2023). However, source-level evidence alone cannot establish thematic dominance; that proposition requires empirical confirmation through keyword and conceptual-structure analyses.

Overall, the publication landscape portrays e-learning as a multidisciplinary and relatively decentralised field in which high publication volume does not necessarily reflect strong scholarly influence. The findings extend the literature by showing that the contemporary evolution of e-learning is communicated through a mix of specialised educational journals, interdisciplinary outlets, and technology-oriented conference series. This fragmentation of publication venues strengthens the rationale for science mapping, as journal-level rankings alone cannot reveal whether superficially dispersed outlets contribute to shared intellectual themes or support relatively separate technological, pedagogical, and disciplinary research streams.

4.7 Thematic Clusters Analysis

This section explores the conceptual structure and literature of e-learning literature by analysing the co-occurrence of author keywords and identifying key research themes, gaps and emerging areas. In doing so, it addresses the fourth research question. Network visualisation techniques were employed to examine the interconnectedness of these themes and provide valuable insights for future research and policy developments. Figure 3 visualises the co-occurrence patterns of author-generated keywords in e-learning research. Using a robust analytical approach, VOSviewer was applied for a co-occurrence analysis, a method that integrates multiple techniques to reveal intricate relationships among terms. A full-counting method was applied to ensure a thorough accounting of keyword co-occurrence frequencies. To be specific, an inclusion threshold of at least five co-occurrence instances was established out of the total 4,752 keywords analysed. A total of 238 keywords met or exceeded this threshold, significantly contributing to the structure and clarity of the network visualisation and resulting in distinct thematic clusters.

Figure 3 illustrates these clusters using colour coding, offering a detailed, structured view of interconnections within e-learning research. The network was analysed by theme, focusing on total link strength, key parameters, prominent topics, structural relationships, and publication characteristics. The interpretation relies on three primary visual dimensions: node size (relative importance or frequency), node colour (thematic cluster categorisation), and spatial distance/connection (conceptual relatedness).

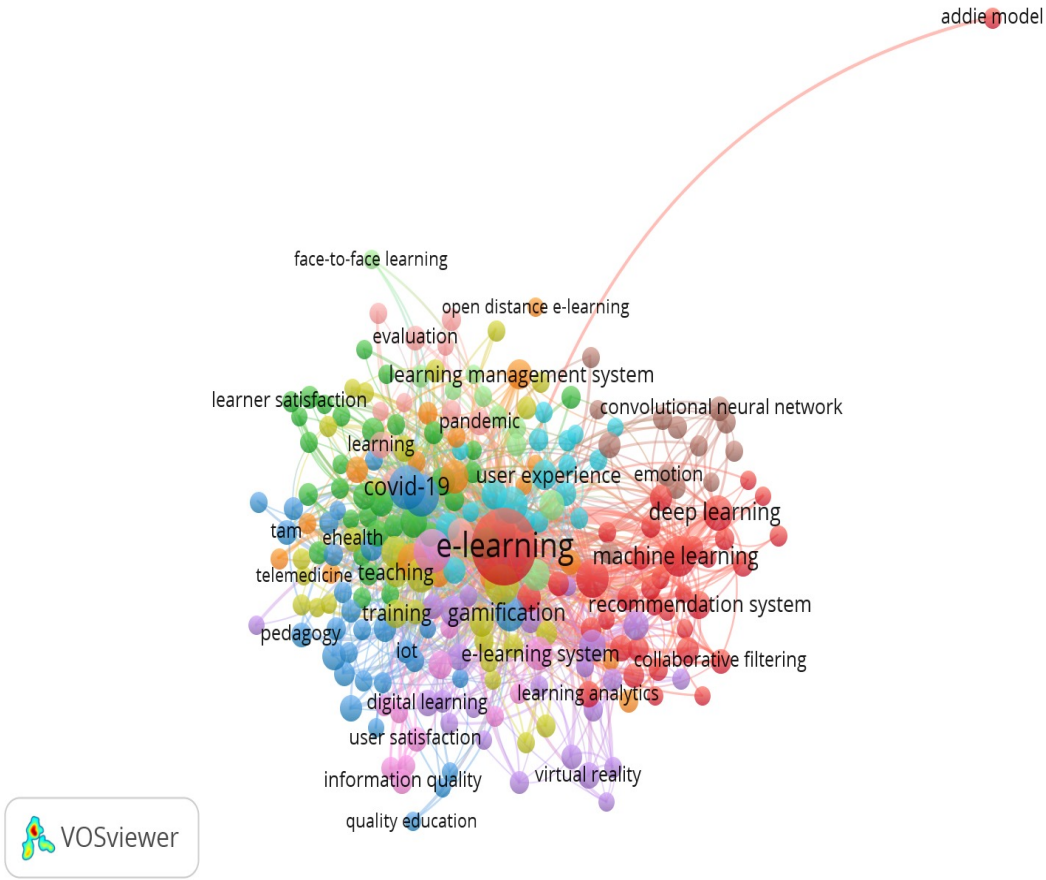


Figure 3 *Network visualisation*
Source: Generated by the author(s) using VOSviewer (van Eck & Waltman, 2014)

The keyword co-occurrence network shows that contemporary e-learning scholarship is organised around a dense technological-pedagogical core, accompanied by several more specialised peripheral streams. "e-Learning" occupies the central position and is closely connected with terms related to machine learning, deep learning, gamification, user experience, learning management systems, learning analytics, learner satisfaction, digital learning, and technology acceptance. The density of these connections suggests that the field is no longer structured around a single question of whether digital learning should be adopted. Instead, its intellectual centre increasingly concerns how e-learning systems are designed, experienced, evaluated, and technologically enhanced. This configuration extends earlier work on e-learning adoption and technology acceptance by indicating that behavioural and implementation questions now coexist with computational and adaptive approaches rather than functioning as separate research agendas (Lin et al., 2021; Martins et al., 2024; Wang et al., 2024).

The network visualisation identifies seven colour-coded thematic clusters, indicating that contemporary e-learning research is organised across interconnected but distinguishable intellectual streams. The red cluster, which occupies a prominent position around the central e-learning node, can be characterised as Artificial Intelligence and Intelligent E-Learning Systems, incorporating machine learning, deep learning, recommendation systems, and collaborative filtering. This structural prominence aligns with the growing integration of AI and intelligent technologies into e-learning research documented by Jia et al. (2022), Gligorea et al. (2023), and Liu and Yu (2023).

The green cluster, labelled Learner Experience, Satisfaction and Learning Evaluation, concentrates on learner satisfaction, evaluation, learning processes, COVID-19, and face-to-face learning. Its position indicates that learner-centred concerns remain closely integrated with contemporary technological developments rather than being displaced by them. This stream is compatible with research emphasising behavioural responses, learning experience, and transitions toward online learning (Lin et al., 2021; Wang et al., 2021).

The blue cluster, conceptualised as Digital Pedagogy, Training and Learning Quality, brings together pedagogy, training, digital learning, information quality, quality education, and technology-acceptance-related concepts. This cluster represents the educational and evaluative foundations of e-learning and suggests that questions of instructional quality continue to coexist with increasingly technological research priorities.

The purple cluster, termed Gamification and Emerging Digital Learning Environments, incorporates gamification, e-learning systems, virtual reality, and user satisfaction. Its position between technological and learner-oriented nodes is theoretically meaningful because gamification bridges system design and learner engagement. This interpretation corresponds with Khaldi et al. (2023), who emphasise the role of gamification mechanisms in supporting engagement within higher-education e-learning environments.

The yellow cluster, labelled Learning Management and Distance Education, includes learning management systems, open distance e-learning, teaching, and specialised applications such as telemedicine. It represents the delivery and organisational infrastructure through which digital learning is operationalised across different educational contexts.

The cyan or turquoise cluster, described as User Experience and Technology-Enhanced Learning, concentrates on user experience and related digitally mediated learning applications. Its proximity to the central network suggests that interaction quality and system usability remain integral to understanding how learners engage with increasingly complex digital environments.

Finally, the brown or maroon cluster, labelled Computational and Neural Learning Applications, contains specialised concepts such as convolutional neural networks. This comparatively focused stream reflects the penetration of advanced computational methods into e-learning research, particularly for classification, prediction, and data-driven educational applications, consistent with Pathak and Kashyap (2023).

In contrast, ADDIE appears to belong to the red cluster by colour, although it is spatially peripheral. Therefore, ADDIE is classified as a separate pedagogical cluster because of its broad conceptual scope. ADDIE is weakly connected to the broader red cluster despite sharing cluster membership, and the bibliometric findings suggest limited integration with the dense core of Artificial Intelligence (AI)- and machine learning-oriented research.

5. CONCLUSION

This study conducts a comprehensive bibliometric analysis of e-learning, revealing significant findings on research themes and evolving trends within the field. The analysis identifies thematic clusters and keywords in previous scholarly research. Specifically, the analysis identifies core thematic clusters and keywords in scholars' previous research. Keywords such as e-learning, gamification, artificial intelligence (AI), and machine learning (ML) are highly cited and underscore the dynamics of e-learning research, emphasising the importance of exploring it. Conversely, the findings reveal relatively little exploration of pedagogical frameworks, particularly within the "Pedagogical and Training Context" cluster, where foundational instructional design models such as the ADDIE framework receive limited scholarly attention. In essence, while e-learning research expands through the multidisciplinary integration of advanced technologies such as artificial intelligence (AI), machine learning (ML), and gamification, its pedagogical and instructional foundations remain comparatively under-researched. This bibliometric study provides a robust foundation and valuable body of knowledge for academicians, practitioners and higher education institutions. Ultimately, it provides clear direction for future research by highlighting emerging technological trends alongside critical pedagogical gaps.

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8. AUTHORS' CONTRIBUTIONS

Pg Mohd Auza'e Pg Arshad contributed to the conceptualisation of the study, literature review, bibliometric analysis, and drafting of the results. Nurul Aina Johari contributed to the literature review and manuscript formatting. Both authors provided constructive feedback and collaborated closely throughout the research process, analysis, and development of the final manuscript.

9. CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this article.

10. DECLARATION OF GENERATIVE AI IN THE WRITING PROCESS

The authors are non-native English speakers. Therefore, the authors used the large language model (LLM) ChatGPT 5.2 to proofread and refine the paper's language. The authors produced the core intellectual content, data analysis, and interpretation independently, based on bibliographic records extracted from the Scopus database. The study used BibliomGIK, OpenRefine, and VOSviewer to analyse the data. The authors reviewed, edited and verified all generated text, taking full responsibility for the final content of this publication.

11. DATA AVAILABILITY/SUPPLEMENTARY MATERIALS

All data produced and analysed in this study are fully included within the published article.

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