PPSDP International Journal of Education
Volume 4 (2) (Special Issue) 5-7 November 2025, 418-444
3rd PPSDP International Conference on Educational Sciences (IConEds 2025)
E-ISSN 2829-5196, P-ISSN 2830-3229

Global Trends in Higher Education and Learning Technology: A Comprehensive Bibliometric Study

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Article History: Received on 8 September 2025, Revised on 6 October 2025, Published on 1 December 2025

Abstract: This study examines the decade-long development of research on independent learning, higher education, and learning technology from 2016 to 2025, addressing the lack of a holistic synthesis that integrates trends, collaboration patterns, and thematic evolution in this interdisciplinary field. Using a bibliometric approach, data were extracted from the Scopus database (n = 697) and analyzed through VOSviewer and Biblioshiny to map the intellectual, conceptual, and social structures of the domain. The results reveal a substantial increase in research output, particularly between 2022 and 2024, with China, Indonesia, and Malaysia emerging as leading contributors and authors such as Zhang X. and Wang X. playing central roles. Influential publication venues include the *International Journal of Educational Technology in Higher Education* and *Sustainability*. Keyword analyses highlight dominant themes such as higher education, e-learning, and artificial intelligence, alongside emerging topics including ChatGPT, gamification, and machine learning, indicating a shift toward personalized and intelligent learning environments. These findings underscore the accelerating global transformation of technology-enhanced education and point to the need for further research that integrates pedagogical, technological, and policy perspectives to support the development of adaptive and equitable learning ecosystems.

Keywords: Artificial Intelligence, Bibliometric Analysis, Higher Education, Independent Learning, Learning Technology

A. Introduction

Independent learning, the transformation of higher education, and the integration of technology have become central themes in contemporary educational discourse. The digitalization of education and the proliferation of online platforms have fundamentally reshaped the delivery and experience of learning, particularly in higher education institutions across both developed and developing countries (Ngalomba et al., 2025). At the intersection of lifelong learning and technological innovation lies the need to equip learners with essential 21st-century competencies

such as adaptability, self-regulation, and digital literacy (Kaspruk et al., 2025). In this evolving context, e-learning and virtual environments are increasingly used to enhance student engagement and foster learning autonomy. The convergence of technology and pedagogy now spans multiple disciplines from healthcare training (S. Niu et al., 2025) to engineering education (Böck et al., 2025). The COVID-19 pandemic further accelerated this transformation, pushing educational systems worldwide to rapidly adopt digital infrastructure and remote learning models (Im & Jakupov, 2025; Pandya et al., 2025). As a result, independent learning practices supported by digital tools have become a key focus of academic inquiry. Understanding how these practices have developed and where they are headed requires systematic investigation.

Despite the growing volume of research on educational technologies and autonomous learning, a clear gap remains in how the field is understood at a global and longitudinal scale. Existing studies typically concentrate on specific instructional innovations such as flipped classrooms (Colque-Quispe et al., 2025) or AI-supported learning systems Zhou et al. (2025) yet they do not integrate these findings into a broader synthesis of how research output, international collaboration, and thematic structures have evolved over time. What is notably absent is a holistic, decade-long analysis that brings together these distributed strands of scholarship. Bibliometric approaches offer the methodological capacity to address this gap, but prior applications have rarely examined the full interplay between publication trends, influential authors and sources, and conceptual evolution across an extended period (Aria & Cuccurullo, 2017; Visser et al., 2021).

Recent bibliometric studies increasingly use tools such as VOSviewer and Biblioshiny to construct co-authorship networks, track institutional influence, and analyze thematic development in educational technology research (Aria et al., 2024; Eck & Waltman, 2017). These tools produce visual representations of conceptual relationships and collaborative structures. For example, co-occurrence mapping has identified "higher education," "artificial intelligence," and "self-regulated learning" as dominant themes. Trend analyses have also revealed growing attention to immersive technologies like virtual reality (Wittke et al., 2025) and adaptive learning platforms (Rajamäki & Postolache, 2025). Geographically, research production has become more diversified. Countries such as China, Indonesia, and Malaysia are emerging as key contributors to technology-driven educational research (Niu et al., 2024; Prasetia et al., 2025), often emphasizing institutional capacity-building and digital infrastructure. These nations have generated considerable output on themes such as flipped learning (P. Cheng et al., 2025) and virtual mobility (Ngalomba et al., 2025). At the same time, recent studies increasingly explore affective and cognitive dimensions of digital education. Technologies like ChatGPT and AI-based feedback systems have been found to enhance student motivation, satisfaction, and self-efficacy (Sujannah et al., 2025; Uppal & Hajian, 2025). Similarly, gamification and simulation-

based platforms are gaining traction for promoting autonomy and critical thinking (Hidayat et al., 2019; Kunz et al., 2025). These findings emphasize the importance of developing learner-centered and pedagogically grounded digital learning systems.

Despite these advances, notable gaps persist. Many existing studies are confined to specific countries or disciplinary silos (Im & Jakupov, 2025; Sujannah et al., 2025), with limited comparative insight into how institutions, nations, and networks shape research dissemination. Moreover, longitudinal bibliometric studies covering a full decade that integrate both conceptual and empirical dimensions are rare. It remains unclear which themes are foundational, emerging, niche, or in decline (Aria et al., 2024), and little has been done to trace the intellectual impact of key authors and journals.

The novelty of this study lies in its integrative bibliometric design. By combining trend analysis, network visualization, and thematic mapping, this research offers a multidimensional synthesis that previous studies have not provided. Unlike earlier works that examine isolated themes or shorter periods, this study spans a full decade and applies a standardized and replicable protocol to analyze the conceptual, intellectual, and social structures of the field (Visser et al., 2021). To address these gaps, this study conducts a comprehensive bibliometric analysis of scholarly literature on independent learning, higher education, and learning technology from 2016 to 2025. Specifically, it investigates: (1) the growth trajectory of research output; (2) the most prolific sources, authors, and countries; (3) dominant and emerging keywords; and (4) thematic evolution across time. This study's novelty lies in its integrative approach, combining trend analysis, network visualization, and thematic mapping to offer a multidimensional perspective of the research field. Unlike previous works, this study spans an entire decade and applies a standardized analytical protocol rooted in established best practices (Visser et al., 2021). The scope is limited to English-language, peer-reviewed articles, conference proceedings, book chapters, and reviews indexed in Scopus.

B. Methods

This study employed a bibliometric mapping approach to examine the scientific landscape of independent learning, higher education, and learning technology over a ten-year period from 2016 to 2025. Bibliographic data were sourced from the Scopus database (https://www.scopus.com), a widely recognized academic indexing platform known for its extensive coverage and reliable metadata (Visser et al., 2021). Data were retrieved on August 2, 2025, using a structured search query applied to titles, abstracts, and keywords (TITLE-ABS-KEY) with the phrase: "*independent learning, higher education, and learning technology.*" This search string was selected to capture the intersection of pedagogical, institutional, and technological dimensions of education. From the initial search, 1,025 records were retrieved. A refinement process was applied to ensure data quality and relevance. Only documents written in English and published within the 2016–2025 timeframe were considered. Inclusion

was limited to four types of peer-reviewed literature: journal articles, conference papers, book chapters, and reviews. After filtering, 697 documents remained and were used as the final dataset for bibliometric analysis.

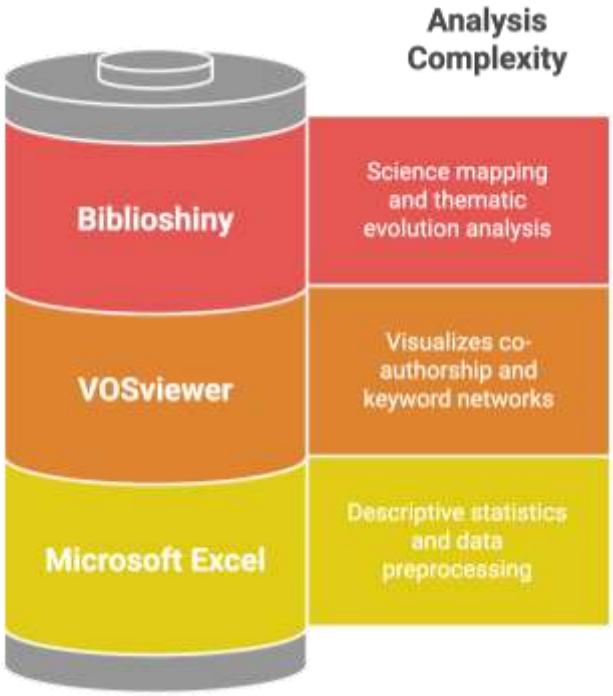

Figure 1. Hierarchy of Analysis Complexity in Bibliometrics: Excel, VOSviewer, and Biblioshiny

The retrieved data were exported in two formats CSV (comma-separated values) and RIS (Research Information Systems) to enable flexible processing across multiple analysis tools. Preprocessing was conducted using Microsoft Excel, which included standardization of author names, disambiguation of institutional affiliations, harmonization of keywords, and removal of duplicate entries. The cleaned dataset included variables such as publication year, document type, source title, authorship, institutional affiliation, country of origin, citation count, and keywords. Standardization was essential to ensure accurate construction of co-authorship and co-occurrence networks (Bancong, 2024). Three main tools were used in the analysis: Microsoft Excel for descriptive statistical summaries and data preprocessing. VOSviewer for visualizing co-authorship, keyword co-occurrence, and bibliographic coupling networks. Biblioshiny, the web interface of the *bibliometrix* R package, for advanced science mapping and thematic analysis (Aria & Cuccurullo, 2017). The analytical pipeline followed established protocols in bibliometric studies (Aria et al., 2024), which encompassed conceptual, intellectual, and social structure mapping. Conceptual structures were analyzed through co-word analysis and Multiple Correspondence Analysis (MCA), while intellectual structures were examined via co-

citation networks. Social structures such as international collaborationw were revealed using bibliographic coupling and co-authorship matrices. Several key bibliometric indicators were computed to capture the dynamics of the field: Annual Scientific Production: Distribution of publications by year from 2016 to 2025. Source Impact**:** Based on citation count, h-index, and publication volume. Authorship Patterns**:** Total number of publications, average citations per author, and productivity trends. Keyword Co-occurrence: Thematic clustering and frequency analysis using visual network mapping. Geographic Collaboration: Comparison of Single Country Publications (SCP) and Multiple Country Publications (MCP). Thematic Evolution: Mapping research transitions through a three-phase longitudinal diagram.

Descriptive statistics were processed in Microsoft Excel to identify distribution by year, source, and type. For advanced analyses, the *bibliometrix* R package and Biblioshiny interface were used to generate trend topic models, thematic maps, and strategic diagrams. VOSviewer's clustering algorithm enabled visualization of high-frequency keyword networks using optimal thresholding for clarity. Citation-based clustering and bibliographic coupling were also applied to evaluate the intellectual proximity of countries, authors, and source titles (Eck & Waltman, 2017). In alignment with established best practices (Visser et al., 2021), Scopus was considered a comprehensive and stable source for interdisciplinary and educational bibliometric studies.

C. Results and Discussion

Figure 2 shows the annual distribution of publications on independent learning, higher education, and learning technology from 2016–2025, based on Scopus data (697 documents including articles, conference papers, and reviews). The overall trend indicates steady growth, with 34 publications in 2016 rising to 139 in 2024 the decade's peak before slightly declining to 97 in 2025. This trajectory reflects growing scholarly engagement, particularly after 2020, driven by institutional investment in digital learning and pedagogical innovation. The sharp post-2020 expansion aligns with global educational disruptions caused by COVID-19 and subsequent adoption of digital systems. Between 2016 and 2024, scholarly output increased by ≈19% annually, peaking in 2024 with a 36% year-over-year rise from 2023. The 2025 decline (−30%) is best interpreted as a temporary indexing lag and thematic pivot toward specialized subfields integrating artificial intelligence, cognitive analytics, and adaptive feedback systems. Academically, this evolution signals a transition from reactive digital adoption to a more strategic, evidence-based phase of research on independent learning and technology integration. The dataset limited to English-language, Scopus-indexed publications retrieved August 2 2025 offers a conservative estimate but clearly illustrates the field's post-pandemic consolidation around sustainable, data-driven innovation.

Table 1. Highly Cited Independent Learning, Higher Education, And Learning Technology Research

Rank	Title	Year	Source Title	TC	Author
1	Classifying Cognitive Load In Digital Textbook Reading Using Electroencephalogram Signals	2025	2025 13th International Conference on Information and Education Technology, ICIET 2025	0	(Wittke et al., 2025)
2	Evaluating The Effectiveness of a Novel Digital Evaluation Technology on Dental Preclinical Crown Preparation Training	2024	Journal Of Dental Education	2	(Chen et al., 2024)
3	Study On Mode of Cultivating Computational Thinking in Online Teaching of Information Technology: A Quasi-Experimental Study	2024	ACM International Conference Proceeding Series	0	(Yang et al., 2024)
4	Optimization Of Practical Path of Teaching Reform in Higher Education - Based on Distributed Logistic Model Application	2024	Applied Mathematics and Nonlinear Sciences	0	(Zhang & Lu, 2024)
5	From ChatGPT to China' Sci-Tech: Implications for Chinese Higher Education	2023	Beijing International Review of Education	11	(Zhang et al., 2023)
6	Online Homework Intelligent Platform Based on Self-Regulated Learning (SRL): Essential for Sustainable Development of Online Higher Education	2022	Sustainability (Switzerland)	9	(Liu et al., 2022)
7	Enhancing Anatomy Education with Virtual Reality: Integrating Three-Dimensional Models for Improved Learning Efficiency and Student Satisfaction	2025	Frontiers In Medicine	0	(Niu et al., 2025)
8	Optimization And Realization Path of Moral Education Flipped Classroom Teaching Model Based on Intelligent Computing in Colleges and Universities	2025	Journal Of Combinatorial Mathematics and Combinatorial Computing	0	(Cheng et al., 2025)
9	Evaluating Project Based Learning in Science and Technology Education: A Statistical Approach Within Education Informatization Governance	2025	Proceedings Of 2024 2nd International Conference on Information Education and Artificial Intelligence, ICIEAI 2024	0	(Wang, 2025)
10	The Integrated Teaching Practice Of Medical Cloud	2025	BMC Medical Education	0	(Zhang et al., 2025)

	Dictionary Development And Project-Based Learning				
11	Serum Metabolic Fingerprints Encode Functional Biomarkers for Ovarian Cancer Diagnosis: A Large-Scale Cohort Study	2025	Ebiomedicine	0	(Liu et al., 2025)
12	Evaluating The Effectiveness of a Novel Digital Evaluation Technology on Dental Preclinical Crown Preparation Training	2024	Journal Of Dental Education	2	(Chen et al., 2024)
13	Study On Mode of Cultivating Computational Thinking in Online Teaching of Information Technology: A Quasi-Experimental Study	2024	Acm International Conference Proceeding Series	0	(Yang et al., 2024)
14	The Relationship Between Homework Time and Academic Performance Among K-12: A Systematic Review	2024	Campbell Systematic Reviews	5	(Guo et al., 2024)
15	Effectiveness Of an Optional Breastfeeding Course for Multidisciplinary Undergraduate Healthcare Students: A Quasi-Experimental Study	2023	Nurse Education in Practice	2	(Yu et al., 2023)
16	Methods Of Improving and Optimizing English Education in Colleges and Universities Assisted by Microvideo Technology	2022	Scientific Programming	2	(Wang, 2022)
17	Innovation Of English Course Network Learning Model Based on Literature Data Mining Technology	2022	Lecture Notes on Data Engineering and Communications Technologies	0	(Li, 2022)
18	Analysis Of O2o Teaching Assistant Mode of College English in MOOC Environment	2022	Journal Of Environmental and Public Health	3	(Y. Zhang, 2022)
19	The Effect of Two Educational Technology Tools on Student Engagement in Chinese EFL Courses	2021	International Journal of Educational Technology in Higher Education	47	(Teng & Wang, 2021)
20	Research On the Development and Operation of Pre-School Dance Online Course Based On "Internet +"	2021	ACM International Conference Proceeding Series	0	(Li, 2021)
21	Research And Implementation of Teaching System for Higher Vocational Specialty Courses	2019	Proceedings - 10th International Conference on Information Technology in	1	(Zhang et al., 2019)

	Based on Hybrid Teaching Mode		Medicine and Education, ITME 2019		
22	Research And Implementation of Teaching System for Higher Vocational Specialty Courses Based on Hybrid Teaching Mode	2019	Proceedings - 10th International Conference on Information Technology in Medicine and Education, ITME 2019	1	(Zhang et al., 2019)
23	An Optoelectrical Professional's Training Model Based on Unity of Knowing and Doing Theory	2017	Proceedings Of SPIE - The International Society for Optical Engineering	0	(Qin et al., 2017)
24	Exploring Factors That Influence Technology-Based Distractions in Bring Your Own Device Classrooms	2017	Journal Of Educational Computing Research	31	(Kay et al., 2017)
25	Realization And Application of Multimedia Video System Based on Web Server in Teaching of Engineering Measurement	2016	International Journal of Emerging Technologies in Learning	2	(Wang, 2016)

Table 1 lists the 25 most cited research articles on independent learning, higher education, and learning technology (2016–2025), based on Scopus data. The top-cited study is Teng & Wang (2021)"*The Effect of Two Educational Technology Tools on Student Engagement in Chinese EFL Courses*", which received 47 citations indicating strong impact in the discourse on engagement and digital tools. Other notable entries include Zhang et al. (2023) on *ChatGPT and Chinese Higher Education* (11 citations), and Liu et al. (2022) on *Self-Regulated Learning Platforms* (9 citations). Guo et al. (2024) systematic review on homework time and academic performance (5 citations) adds a behavioral dimension to the discussion. Most high-impact articles were published between 2021–2024, a period marked by intensified research interest in AI, learner autonomy, and adaptive technologies. Articles from 2025 remain largely uncited, consistent with temporal citation bias, not lack of relevance a common lag in bibliometric data accumulation. Thematic implications, these highly cited works reflect a field transitioning from infrastructure-based digital adoption to personalized, adaptive, and motivation-centered learning models.

Most Relevant Sources

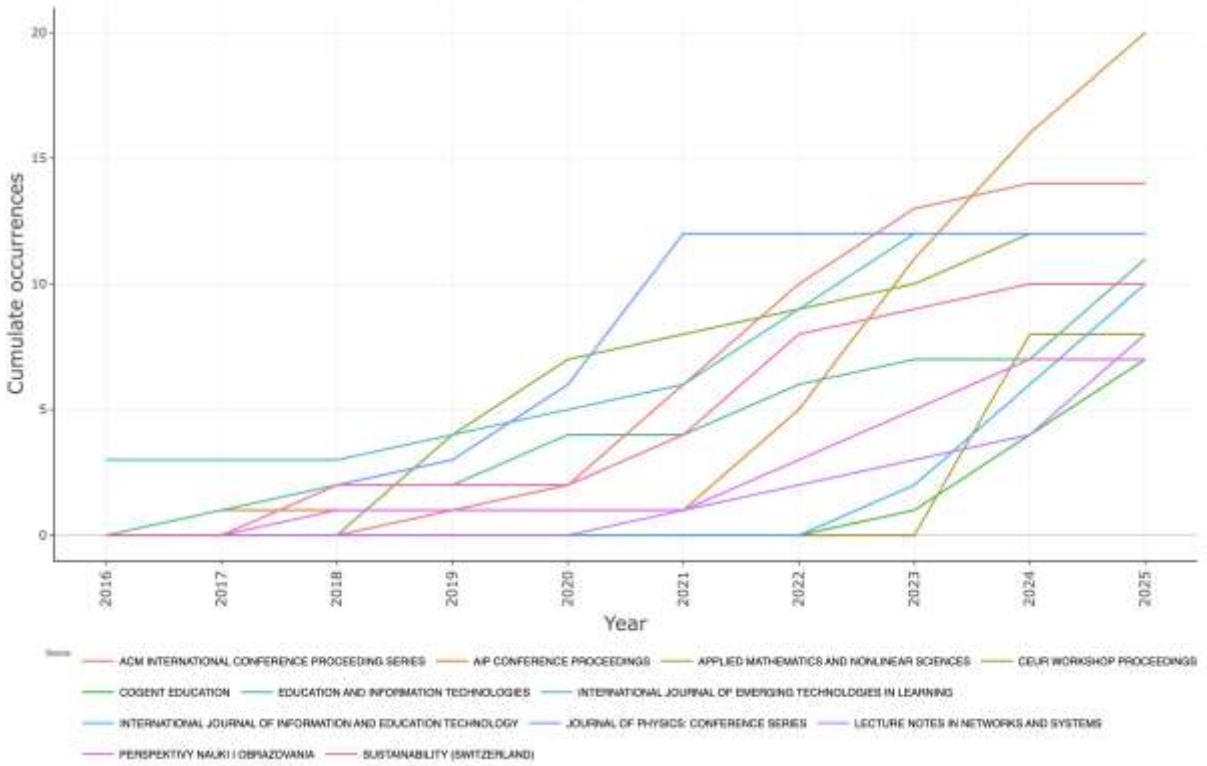

Figure 2. Sources' production over time

Figure 2 presents the cumulative number of publications from 2016 to 2025 in the most prominent sources addressing independent learning, higher education, and learning technology. The graph visualizes distinct publication trajectories across a variety of peer-reviewed journals and conference proceedings. Among the leading sources, AIP Conference Proceedings demonstrates the most significant growth, particularly after 2021, and reaches the highest cumulative total by 2025. This trend suggests a rising interest in presenting educational technology research through technical conference platforms. Similarly, the ACM International Conference Proceeding Series shows steady and consistent growth beginning in 2020, indicating its continued relevance for disseminating work on digital learning environments and computational methods in education. Sustainability (Switzerland) emerges prominently after 2021, reflecting increasing scholarly engagement with the intersection of sustainable development and higher education technology. A particularly sharp increase is observed in Applied Mathematics and Nonlinear Sciences between 2024 and 2025, suggesting a recent integration of mathematical modeling approaches into pedagogical research. Journals such as Education and Information Technologies, Cogent Education, and the International Journal of Emerging Technologies in Learning display moderate yet consistent growth, reflecting a stable base of publications on the topic. In contrast, sources like the Journal of Physics: Conference Series and CEUR Workshop Proceedings show more sporadic increases, indicating occasional but relevant

contributions to the field.

Table 2. 10 most source titles that contribute to the publication on independent learning, higher education, and learning technology independent learning, higher education, and learning technology

Rank	Relevant sources	Document	Citation	Total link strength
1	ACM International Conference Proceeding Series	14	17	0
2	Aip conference proceedings	20	18	0
3	Bmc medical education	6	199	0
4	Sustainability (Switzerland)	10	353	0
5	Ceur workshop proceedings	13	188	0
6	Education and information technologies	12	203	0
7	Education science	6	148	0
8	International journal of educational techmology in hinger education	5	743	0
9	Frontiers in Psychology	5	142	0
10	International journal of emerging technologies in learning	12	237	0

Table 2 highlights the ten most prolific source titles in the field. While *AIP Conference Proceedings* (20 documents) and *ACM International Conference Proceeding Series* (14 documents) lead in volume, both exhibit relatively low citation counts 18 and 17 respectively—suggesting limited long-term academic influence. In contrast, *Sustainability (Switzerland)* (10 publications, 353 citations) and *Education and Information Technologies* (12 publications, 203 citations) reflect a stronger balance between productivity and scholarly engagement. The standout source is the *International Journal of Educational Technology in Higher Education* (IJETHE), which, despite only five publications, has amassed 743 citations indicating exceptional visibility and influence.

Other impactful sources include *BMC Medical Education* (6 documents, 199 citations), *CEUR Workshop Proceedings* (13 documents, 188 citations), and interdisciplinary contributors like *Frontiers in Psychology* and *Education Sciences*, all of which bridge psychology, pedagogy, and technological innovation. This pattern reveals that **citation impact is not determined solely by volume**. Journals at the intersection of technology and pedagogy particularly those with methodological rigor and thematic relevance tend to generate stronger academic influence. **Strategic implications.** For researchers aiming to maximize impact, journals like *IJETHE* and *Education Sciences* offer more durable scholarly traction than conference proceedings, which while useful for early dissemination often lack sustained visibility. Aligning journal selection with both content maturity and target readership is essential for optimizing reach and

contribution to the field.

Most Influential Authors

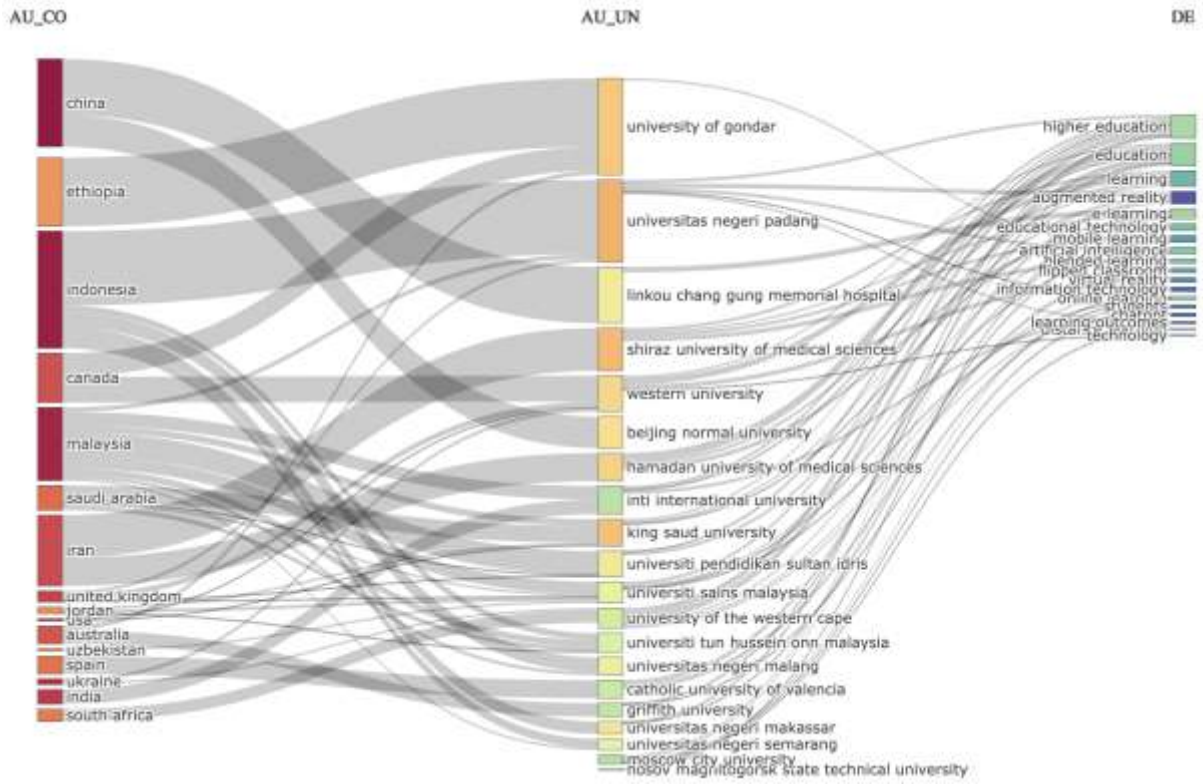

Figure 3. Three field plot of affiliation, countries, keywords

Figure 3 displays a three-field plot linking countries, institutional affiliations, and research keywords in the domains of independent learning, higher education, and learning technology. Among the leading contributors, China, Ethiopia, and Indonesia dominate both in volume and thematic centrality. Their core institutions Linkou Chang Gung Memorial Hospital**,** University of Gondar**, and** Universitas Negeri Padang are strongly associated with central themes such as *e-learning*, *augmented reality*, *flipped learning*, and *AI*, indicating a concentrated national push toward digital pedagogy and innovation. In parallel, Malaysia**,** Iran**,** and Saudi Arabia through institutions like *Universiti Sains Malaysia* and *Shiraz University of Medical Sciences* emphasize applied educational technologies, learner satisfaction, and outcome measurement, reflecting a practical orientation in research. In contrast, Western institutions from the UK, US, and Canada occupy more peripheral positions in the network and are linked to specialized topics like *AI-based instruction* and *student feedback*, suggesting narrower but more targeted research focuses. Thematic coherence across China and Indonesia indicates the presence of state-aligned research agendas, particularly in digital transformation and capacity building. Meanwhile, institutions from advanced economies show a more fragmented pattern, aligned with

specialization and refinement rather than system-level overhaul illustrating differing national priorities in educational innovation (Niu et al., 2025; Prasetia et al., 2025).

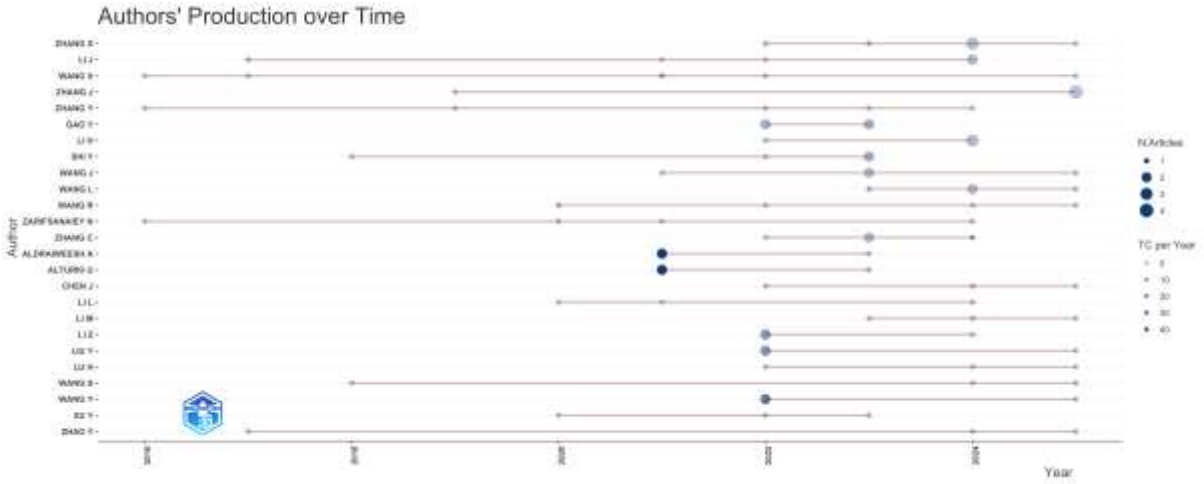

Figure 4. Authors' production over time

Figure 4 visualizes the temporal distribution of author productivity and citation impact from 2016 to 2025. Authors such as Zhang X, Li J, Wang X, and Zhang Y exhibit consistent publication output, with increasing citation strength, particularly between 2021 and 2024. Their sustained activity aligns with their recognition in *Table 1* as the most cited scholars in the field. Conversely, Zafrasahegn N and Alrahmari A show high-impact bursts within shorter publishing windows indicating that impactful contributions can stem from focused work in fast-evolving areas. This is consistent with the findings of (Sujannah et al., 2025; Uppal & Hajian, 2025), who argue that strategic entry into trending topics such as AI-driven education, simulation-based learning, or gamified platforms can yield outsized visibility, even with fewer publications. This distribution shows two key patterns: (1) long-term productivity anchors influence and continuity in the field, while (2) targeted innovation allows emerging scholars to gain rapid recognition in high-demand niches. Bibliometric visibility, therefore, is shaped both by volume and by thematic timeliness.

Most Influential Country

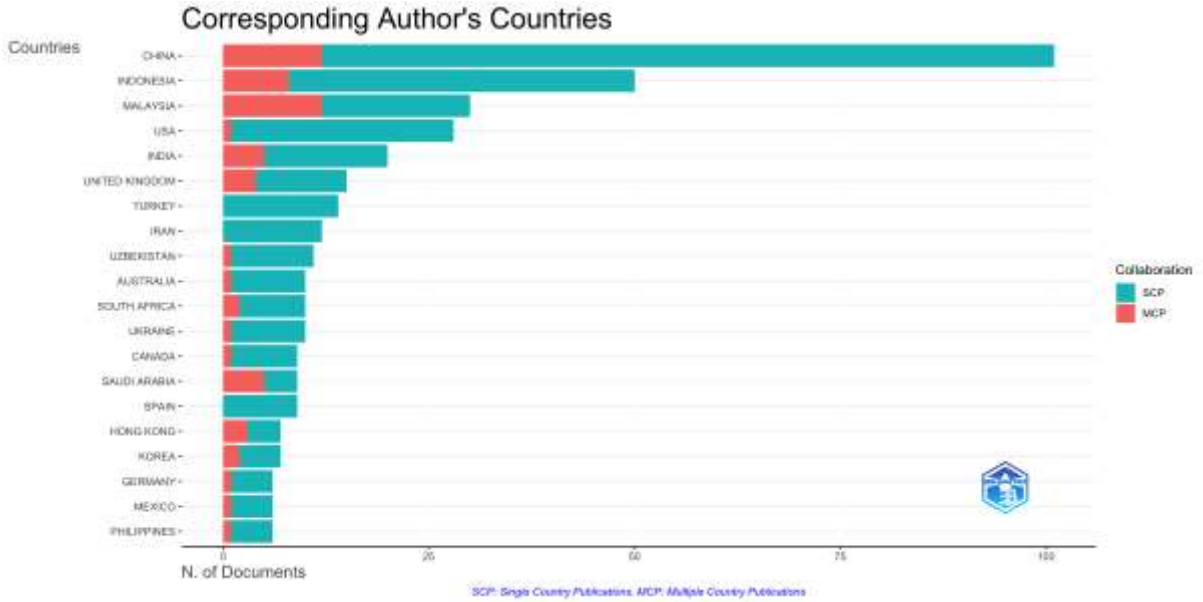

Figure 5. Corresponding author's counties: Geographical collaboration: single-country and multiple-country publications

Figure 5 depicts the distribution of corresponding authors by country, differentiating between Single Country Publications (SCP) and Multiple Country Publications (MCP). China, Indonesia, and Malaysia dominate in SCP, reflecting strong national research ecosystems and alignment with internal digital education agendas. In contrast, the UK, Canada, and Saudi Arabia show a higher share of MCPs, signaling robust international collaboration. These differences reflect two strategic orientations: SCP-heavy countries focus on policy-driven, domestic innovation, while MCP-oriented nations contribute through broader, cross-national academic networks, which often yield higher citation reach and methodological diversity (Aria et al., 2024). This pattern is consistent with institutional and authorship dynamics shown in Figures 4 and 5, where internationally linked contributors often explore globally trending topics like gamification, AI-based instruction, and flipped classrooms. The distinction also mirrors broader geopolitical and academic priorities emerging economies emphasize capacity-building and digital access, while advanced economies concentrate on specialization and international visibility.

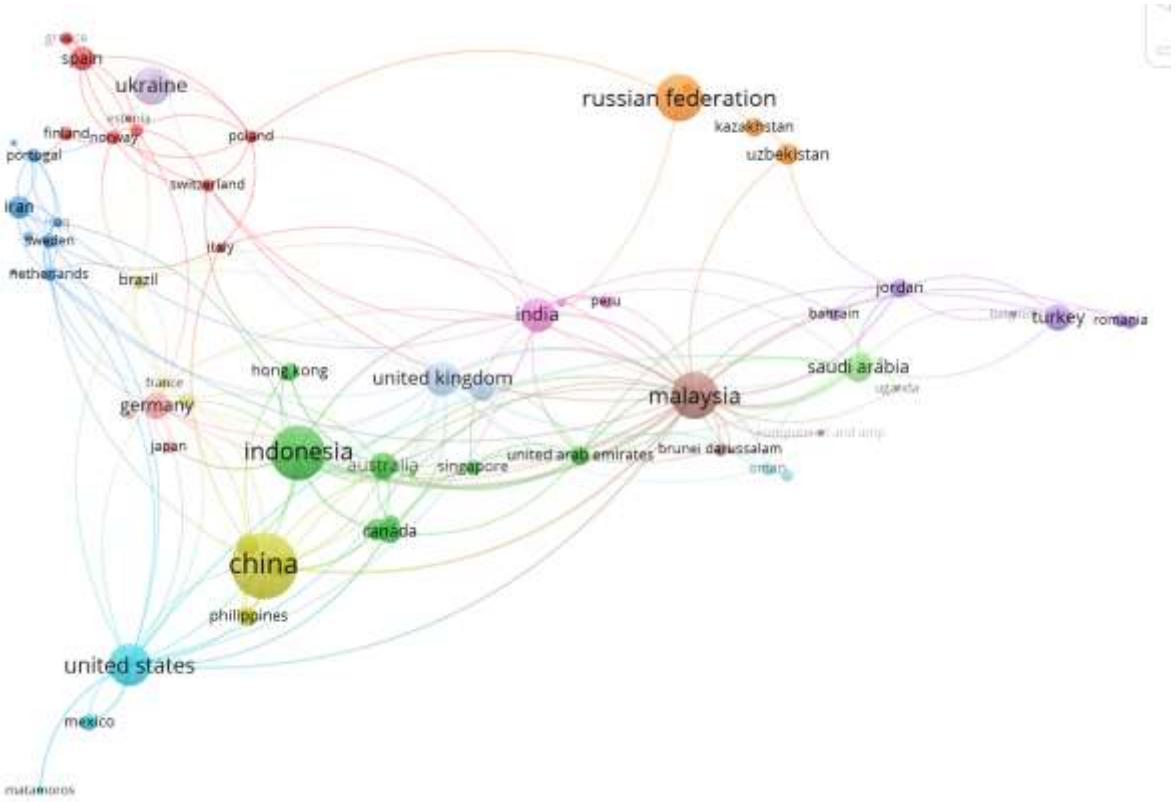

Figure 6. Bibliographic coupling of countries

Figure 6 visualizes bibliographic coupling among countries contributing to independent learning, higher education, and learning technology research. Major nodes, United States, China, Malaysia, and Indonesia demonstrate both high publication volume and strong citation linkages, signaling their centrality in the global knowledge network. The presence of tight bibliographic ties reflects shared research agendas and frequent co-citation, particularly in areas such as AI in education, digital pedagogy, and technology-enhanced learning. Malaysia functions as a regional hub with strong linkages to Saudi Arabia**,** India, and other Southeast Asian nations, indicating active transnational collaboration in Asia. Similarly, China's connections with Indonesia, Germany, UK, and Philippines reflect thematic convergence around e-learning and AI integration. The United States maintains the broadest bibliographic reach across regions, reaffirming its status as a global anchor. Notably, Russia's coupling with Central Asian countries and the UK-Germany-Spain bloc illustrates how regional and linguistic proximity continues to influence collaboration and thematic alignment. These bibliographic patterns reveal both global integration and regional specialization, shaped by epistemic, policy, and institutional factors.

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Most Relevant Keywords

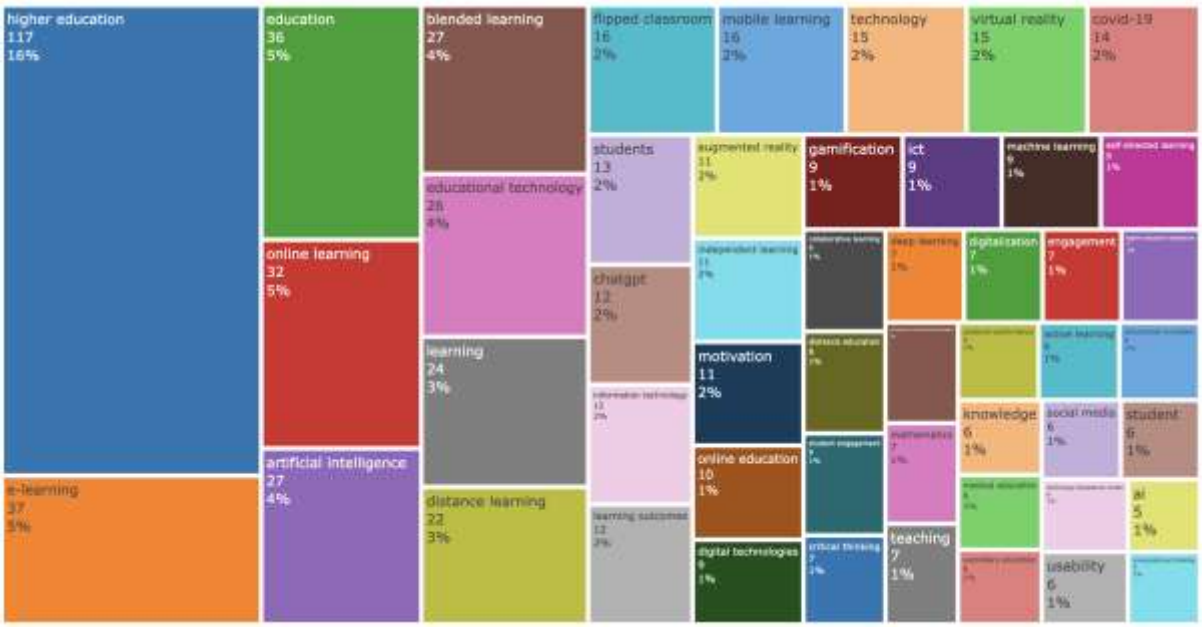

Figure 7. Tree map of authors' keywords

Figure 7 presents a tree map of author-provided keywords found in publications related to independent learning, higher education, and learning technology. This visualization highlights the relative frequency of keyword usage, offering insight into the thematic structure and conceptual focus of the research field. The most frequently occurring term is "higher education", appearing in 117 instances (16%), reaffirming the centrality of tertiary-level learning contexts in this body of literature. Other dominant keywords include "e-learning" (37, 5%), "education" (36, 5%), "online learning" (32, 5%), and both "artificial intelligence" and "blended learning" (each 27, 4%). These terms collectively reflect a strong emphasis on digital learning strategies and the growing integration of intelligent technologies in formal education systems. In addition to established concepts, the map reveals a set of emerging keywords such as *ChatGPT*, *augmented reality*, *gamification*, *motivation*, and *digitalization* signaling a shift toward more experimental, technology-driven pedagogies. These are complemented by learner-centered terms like *student engagement*, *self-directed learning*, *critical thinking*, and *learning outcomes*, which highlight the field's increasing attention to cognitive, affective, and behavioral dimensions of learning. Compared to earlier literature, which primarily focused on traditional online learning environments, the current keyword landscape demonstrates broader thematic coverage and greater responsiveness to recent innovations. The inclusion of contemporary tools (e.g., ChatGPT), immersive modalities (e.g., VR/AR), and advanced instructional models (e.g., flipped classroom and gamification) illustrates the field's dynamic evolution. By capturing both foundational constructs and emergent directions, this study expands the scope of bibliometric analysis. It reveals a research landscape that is not only

grounded in established pedagogical concerns but also rapidly adapting to the opportunities and challenges posed by next-generation educational technologies.

The emergence of terms such as *ChatGPT*, *gamification*, *augmented reality*, and *self-directed learning* signals a deliberate shift toward experimental, student-centered, and affect-sensitive pedagogies. As highlighted by (Sujannah et al., 2025), the integration of conversational AI tools has been linked to increased learner autonomy and motivation. Similarly, studies by (Uppal & Hajian, 2025) show that gamified and immersive learning models support both critical thinking and student engagement. The presence of affective keywords (*motivation*, *satisfaction*, *engagement*) alongside technical ones suggests a blending of cognitive and emotional priorities in the field's evolving research agenda.

The Current Research Landscape

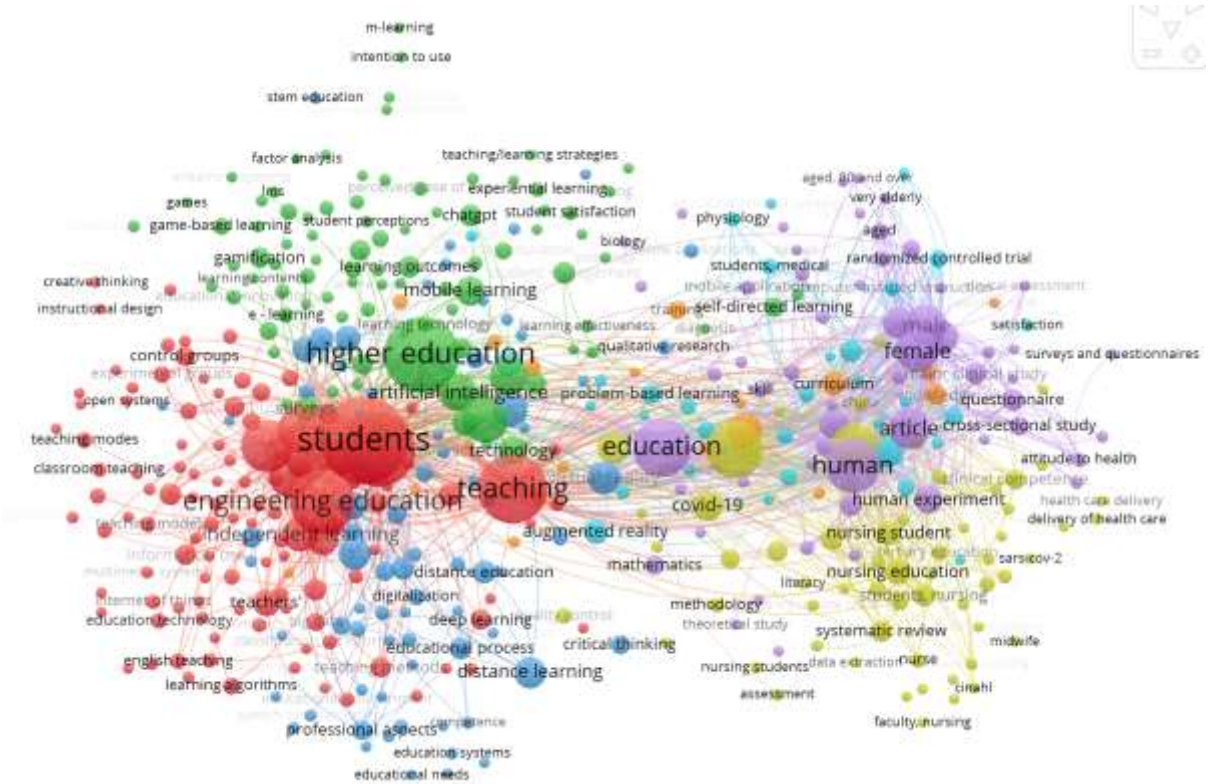

Figure 8. Keywords co-occurrence analysis by network visualization

Figure 8 illustrates a network visualization of keyword co-occurrence in the literature on independent learning, higher education, and learning technology. In this diagram, each node represents a keyword, with its size reflecting the frequency of occurrence. Connecting lines and color-coded clusters denote the strength of thematic association among terms, enabling identification of conceptual groupings within the field. The visualization reveals five dominant clusters, each reflecting distinct yet interconnected

areas of research: The red cluster is centered on *students*, *engineering education*, and *independent learning*, suggesting a strong focus on learner-centered pedagogies within technical and applied science disciplines. The green cluster highlights keywords such as *higher education*, *teaching*, *learning technology*, and *gamification*, representing broad instructional strategies and digital innovation in university-level contexts. The yellow and purple clusters focus on themes such as *education*, *human experiment*, *clinical study*, and *nursing education*, indicating interdisciplinary overlap with health sciences and evidence-based pedagogy. Notably, transversal terms like *artificial intelligence*, *augmented reality*, *digitalization*, and *flipped classroom* are dispersed across multiple clusters. Their widespread presence underscores their transdisciplinary relevance and integrative role in both central and peripheral areas of educational research. The co-occurrence structure points to an ongoing shift in the literature toward technology-enhanced, personalized learning environments and hybrid instructional models. Keywords such as *student satisfaction*, *learning outcomes*, and *critical thinking* emphasize the growing importance of learner impact, assessment, and affective engagement. Viewed in relation to previous findings Figure 8 (tree map of frequency) and Figure 7 (bibliographic coupling) this network consolidates a comprehensive picture of the field's thematic evolution. It demonstrates how traditional educational concerns are being reframed within technologically mediated, interdisciplinary contexts. From a practical perspective, this co-word analysis reinforces the multidimensional nature of contemporary educational innovation. Scientifically, it affirms a clear convergence of diverse academic domains spanning engineering, pedagogy, artificial intelligence, and healthcare within a unified scholarly framework centered on independent and digitally supported learning ecosystems.

The co-occurrence clusters in Figure 8 reveal a field that is both thematically rich and structurally cohesive. The red and green clusters signify a strong interplay between learner-centered frameworks (e.g., self-directed learning, motivation, engagement) and instructional strategies grounded in gamification and learning technology. Meanwhile, the yellow and purple clusters bridge into healthcare and experimental disciplines, highlighting the interdisciplinary scope of digital pedagogy. Notably, transversal keywords such as *artificial intelligence*, *flipped classroom*, and *digitalization* serve as connective tissue, reflecting how core technologies underpin various research subdomains. As suggested by (Uppal & Hajian, 2025), this convergence mirrors a growing integration of cognitive, technological, and emotional learning dimensions within both theoretical and applied contexts.

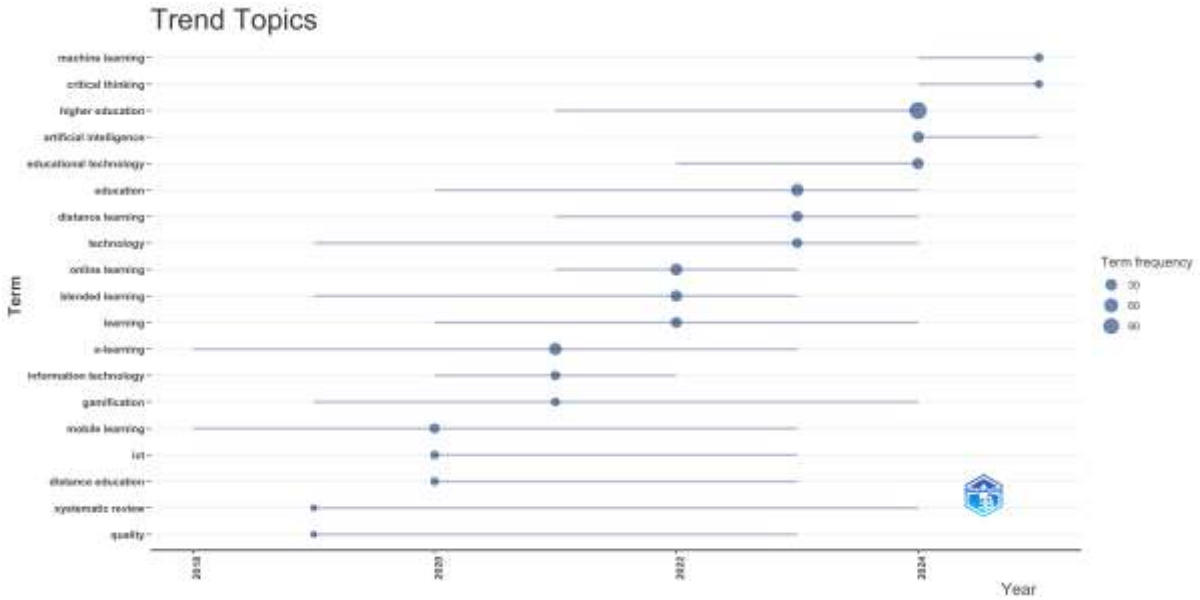

Figure 9. Trend topics of independent learning, higher education, and learning technology

Figure 9 visualizes the evolution of trend topics over time in the field of independent learning, higher education, and learning technology. In this longitudinal map, each node represents a keyword, with node size corresponding to its frequency of usage. The figure captures how research interests have shifted and expanded throughout different phases between 2016 and 2025. In the most recent period (2023–2025), terms such as *machine learning*, *critical thinking*, *higher education*, *artificial intelligence*, and *educational technology* dominate the discourse. These topics signal the field's increasing orientation toward data-driven, intelligent, and cognitive models of learning. Their prominence aligns with global transformations in digital infrastructure, AI development, and the growing demand for advanced learning analytics in higher education. Earlier themes such as *e-learning*, *distance education*, and *online learning* peaked during the COVID-19 pandemic (2020–2022), reflecting an urgent transition to remote learning environments. This reactive phase was later followed by a more deliberate embrace of *blended learning*, *mobile learning*, *gamification*, and *information technology*, indicating a shift toward more sustainable and hybrid instructional strategies. What distinguishes this study is its ability to chart both continuity and change across thematic lines. Rather than offering a static snapshot, the trend analysis captures the layered progression of the field demonstrating how foundational concepts such as *education* and *quality* have been reinterpreted within a rapidly evolving technological landscape. Scientifically, the emerging trends validate the growing importance of interdisciplinary integration, particularly in linking pedagogy with artificial intelligence, machine learning, and cognitive science. Practically, these insights can inform policymakers and educational leaders in aligning curriculum development, technology adoption, and research agendas with future-ready educational goals. In sum, this visualization affirms the field's dynamic nature and

illustrates a clear trajectory toward intelligent, adaptive, and learner-centered education systems—underscoring the transformative potential of educational technology in shaping the next generation of teaching and learning.

The trend timeline in Figure 10 demonstrates a clear three-phase progression in thematic focus: (1) *Crisis-driven adaptation* (2020–2022) dominated by e-learning and distance education during the COVID-19 response, (2) *Stabilization and experimentation* (2022–2024) marked by blended learning, mobile platforms, and gamification, and (3) *Data-intelligent turn* (2023–2025) where keywords such as *machine learning*, *critical thinking*, and *educational technology* take center stage. This layered trajectory reflects the field's evolution from accessibility toward adaptivity, confirming prior findings (e.g., Aria et al., 2024) that link digital maturity with personalized and analytics-enhanced pedagogy. From a research strategy perspective, these shifts suggest increasing relevance for learning analytics, cognitive science, and AI integration as guiding paradigms for future educational design.

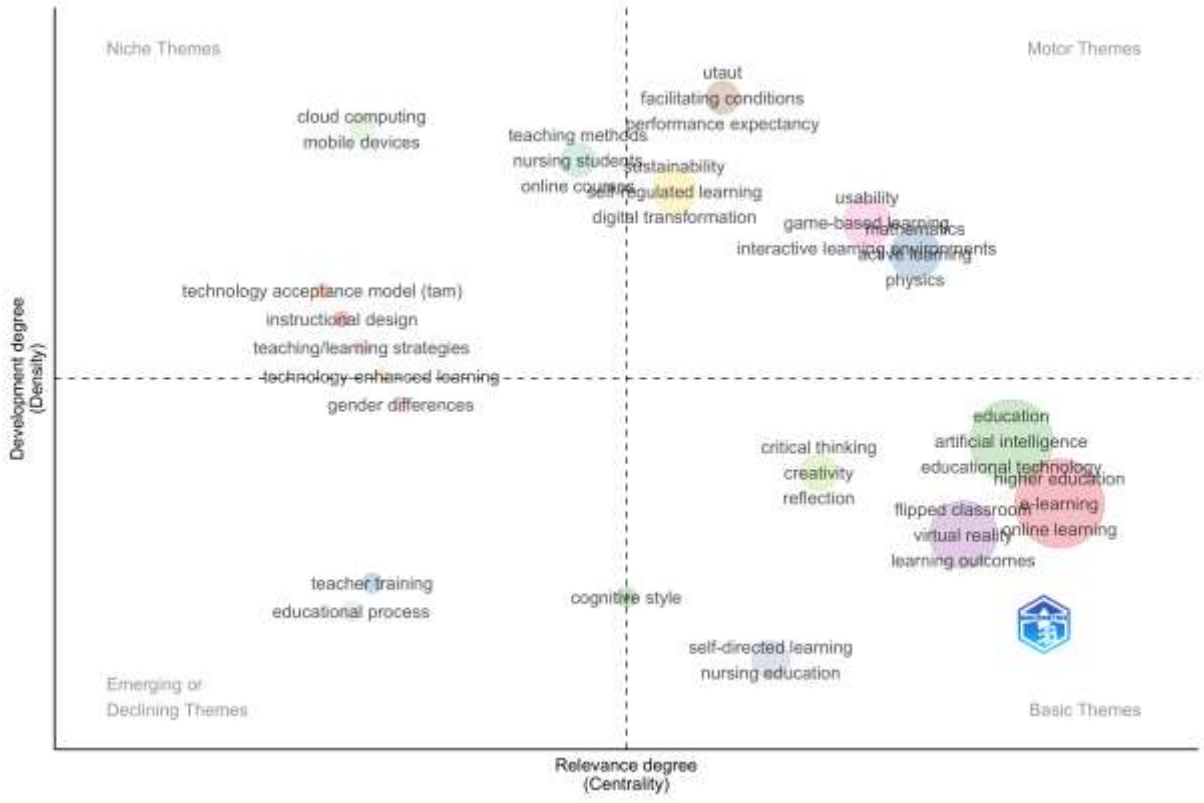

Figure 10. Thematic map of independent learning, higher education, and learning technology

Figure 10 presents a thematic map of research related to independent learning, higher education, and learning technology. The map categorizes themes based on two bibliometric dimensions: centrality (reflecting thematic relevance across the field) and density (reflecting internal development and conceptual maturity). Topics are

positioned within four strategic quadrants: Motor Themes**,** Basic Themes**,** Niche Themes, and Emerging or Declining Themes.

The upper-right quadrant (Motor Themes) includes topics with both high centrality and high density, such as *sustainability*, *performance expectancy*, *digital transformation*, *usability*, *interactive learning environments*, and *game-based learning*. These themes are well-integrated and methodologically mature, forming the core drivers of innovation and theoretical development in educational technology research. The lower-right quadrant (Basic Themes) features frequently cited yet less internally developed topics, including *education*, *artificial intelligence*, *higher education*, *educational technology*, *e-learning*, *flipped classroom*, *online learning*, and *learning outcomes*. These foundational concepts serve as critical connectors across subdomains and represent the conceptual backbone of the field. The upper-left quadrant (Niche Themes) contains topics such as *cloud computing*, *mobile devices*, and *teaching methods*. Although these are well-developed within their respective areas, they hold lower centrality indicating specialization or limited cross-thematic relevance. These themes may cater to specific pedagogical contexts or maturing technological applications. The lower-left quadrant (Emerging or Declining Themes) encompasses underdeveloped and less central topics like *teacher training*, *educational process*, and the *Technology Acceptance Model (TAM)*. These may reflect early-stage explorations or diminishing scholarly focus. However, they could also represent areas with untapped potential, contingent on future empirical validation or cross-disciplinary integration.

Interestingly, terms like *self-directed learning*, *cognitive style*, and *nursing education* are positioned near the central axis, suggesting transitional status. These topics may either consolidate into core themes or evolve toward specialized domains, depending on research uptake and institutional interest. Overall, this thematic mapping offers both a diagnostic lens and a strategic guide for scholars and practitioners. Scientifically, it distinguishes between established paradigms and emerging directions. Practically, it assists curriculum developers, funding agencies, and educational technologists in prioritizing research investments and pedagogical innovation based on thematic maturity and cross-field relevance.

The thematic map in Figure 10 illustrates a healthy ecosystem with robust motor themes (e.g., *digital transformation*, *game-based learning*, *usability*)—indicating both conceptual centrality and methodological depth. The presence of basic themes like *e-learning*, *higher education*, and *AI* further anchors the field's foundational coherence. The niche themes (e.g., *cloud computing*, *mobile devices*) show areas of domain-specific application, while emerging/declining clusters suggest opportunities for revitalization or reframing. The intermediate placement of terms like *self-directed learning* and *cognitive style* signals a transitional zone concepts that may ascend into core paradigms depending on their empirical uptake. As emphasized by Visser et al. (2021), these mappings are essential not only for understanding past emphasis but

also for forecasting strategic growth areas in education research.

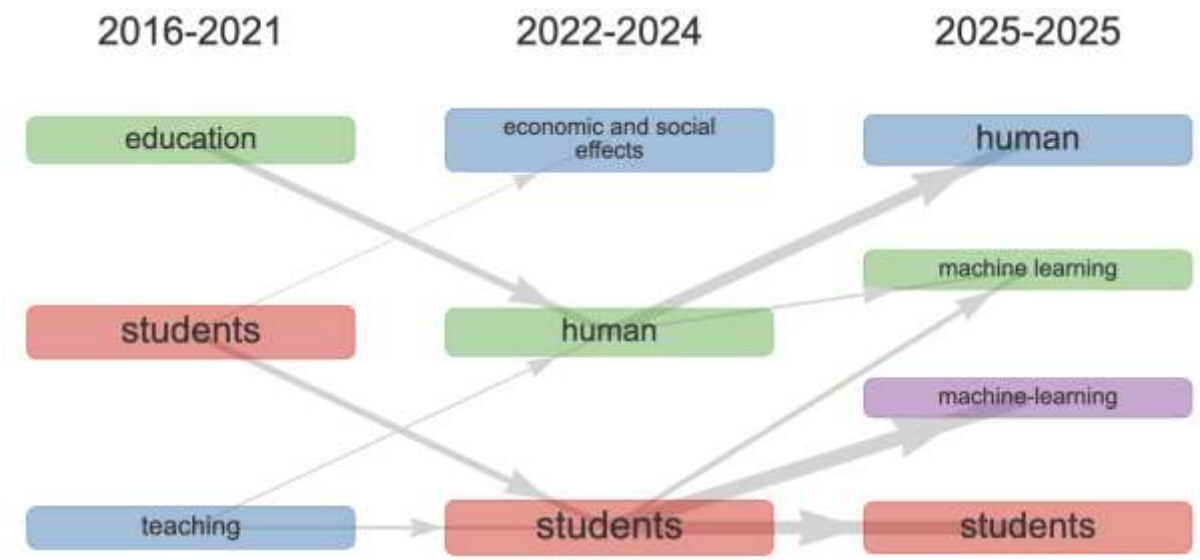

Figure 11. Thematic Evolution of independent learning, higher education, and learning technology

Figure 11 illustrates the thematic evolution of research in the domains of independent learning, higher education, and learning technology across three temporal phases: 2016–2021, 2022–2024, and 2025. The diagram employs directional arrows to map the flow, continuity, transformation, and divergence of core research themes over time. During the initial phase (2016–2021), the field is anchored by foundational concepts such as *education*, *students*, and *teaching*. These themes reflect a primary focus on pedagogical frameworks and learner engagement in conventional or blended learning environments. The sustained presence of *students* as a central node underscores the field's early emphasis on learner-centered paradigms. In the middle period (2022–2024), thematic branches begin to extend toward broader domains, including *human*, *economic*, and *social effects*. This shift indicates an expanding research agenda that integrates human-centric and systemic perspectives, likely driven by the disruptions and reflections induced by the COVID-19 pandemic and the acceleration of digital restructuring in education. Despite these developments, *students* remain a persistent thematic anchor—reinforcing their enduring relevance in the discourse. By 2025, the thematic landscape evolves further into advanced technological territory. Topics such as *machine learning* and *machine-learning* (notably listed as separate entries, reflecting terminological variation) emerge as dominant. These themes maintain direct conceptual ties to *students* and *human*, highlighting a deepening convergence between artificial intelligence applications and human learning models. This evolution suggests a growing emphasis on intelligent, adaptive, and personalized learning systems supported by data and algorithmic feedback. The progression depicted in this figure showcases a research field in dynamic transformation from traditional educational constructs toward a multidisciplinary synthesis of pedagogy, behavioral

science, and AI-driven technology. Scientifically, this underscores the maturation of educational research into a complex, data-rich, and integrative domain. Practically, it signals the urgent need for educators, policymakers, and institutions to align instructional strategies, technology investments, and policy frameworks with this evolving paradigm.

The thematic evolution (Figure 12) reveals a notable continuity anchored in learner focus with *students*, *teaching*, and *education* remaining central throughout all time periods. Yet, the field's trajectory clearly bends toward algorithmic personalization and AI-mediated learning systems, as seen in the 2025 emergence of *machine learning* and its variant forms. The split between "machine learning" and "machine-learning" also underscores the importance of keyword standardization in bibliometric analysis. Conceptually, this evolution from pedagogical constructs to human–AI convergence reflects broader societal and technological trends in how education is personalized, scaled, and governed. As Sujannah et al. (2025) note, adaptive systems are not merely tools they are learning partners, co-structuring both student autonomy and institutional strategies.

D. Conclusions

This study provides a comprehensive bibliometric synthesis of research on independent learning, higher education, and learning technology from 2016 to 2025. The results show a steady rise in scientific output with a peak in 2024 accompanied by expanding international collaboration, the dominance of themes such as higher education, artificial intelligence, and e-learning, and the emergence of innovative areas including ChatGPT, gamification, and immersive technologies. The intellectual and thematic evolution observed over the decade reflects a field transitioning from technology adoption toward more adaptive, data-driven, and learner-centered educational ecosystems. Despite its contributions, this study is subject to several limitations. The exclusive reliance on the Scopus database may introduce coverage bias, especially toward English-language journals and regions with strong Scopus-indexing representation. The search query, although structured, may have been narrow and could have excluded relevant studies using alternative terminology. In addition, the apparent decline in publication output in 2025 may partly reflect an indexing lag and should not be interpreted as a substantive reduction in scholarly activity. These limitations should be considered when interpreting the findings. Future research can build on this study in several concrete ways. First, content analysis or systematic reviews could be conducted on the motor themes identified in the thematic map particularly sustainability, digital transformation, and interactive learning environments to deepen understanding of their conceptual and pedagogical implications. Second, qualitative or mixed-method studies are needed to explore the drivers and mechanisms behind successful multi-country collaboration (MCP), including institutional strategies, funding ecosystems, and researcher networks.

Third, future bibliometric studies may adopt broader or more flexible search strings, incorporate additional databases (e.g., Web of Science, Dimensions), or combine bibliometrics with text mining to capture richer conceptual nuances. Finally, longitudinal case studies could examine how emerging themes such as AI-assisted learning, immersive technologies, and self-directed learning are implemented in real educational settings. By addressing these opportunities, future scholarship can extend, contextualize, and refine the insights presented in this decade-long bibliometric analysis and support the development of more inclusive, intelligent, and evidence-driven educational systems**.**

E. Acknowledgement

We would like to express our sincere gratitude to all individuals and institutions who supported the completion of this study. Special thanks are extended to the Universitas Muhammadiyah Makassar for providing the academic environment and technical support throughout the research process. Appreciation is also directed to the Scopus database and the Bibliometrix R-package team, whose tools were instrumental in conducting the bibliometric analysis. We are particularly grateful to colleagues from the Faculty of Education and postgraduate reviewers who provided constructive feedback during the manuscript development stage. Finally, we acknowledge the valuable assistance of peer collaborators and data analysts who contributed their time and insights to strengthen the rigor and clarity of this publication.

References

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for Comprehensive Science Mapping Analysis. *Journal of Informetrics*, *11*(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007

Aria, M., Cuccurullo, C., D'Aniello, Misuraca, M., & Spano, M. (2024). Comparative Science Mapping: A Novel Conceptual Structure Analysis with Metadata. *Scientometrics*, *129*, 7055–7081. https://doi.org/10.1007/s11192-024-05161-6

Böck, F., Deuerling, A., & Landes, D. (2025). Adaptive Learning Environment Reference Architecture for an Optimised Learning Process. *IEEE Global Engineering Education Conference, EDUCON*. https://doi.org/10.1109/EDUCON62633.2025.11016496

Chen, J., Luo, Y., Li, H., Zhang, X., Yang, Z., Yu, P., Huang, J., Li, J., & Wu, Z. (2024). Evaluating the Effectiveness of a Novel Digital Evaluation Technology on Dental Preclinical Crown Preparation Training. *Journal of Dental Education*, *88*(7), 983–993. https://doi.org/10.1002/jdd.13518

Cheng, P., Mao, L.-F., Shen, W.-H., & Yan, Y.-L. (2025). Electromigration Failures in Integrated Circuits: A Review of Physics-Based Models and Analytical Methods. *Electronics (Switzerland)*, *14*(15). https://doi.org/10.3390/electronics14153151

Cheng, Y., Yue, D., Yan, L., Tong, Q., Zhang, J., Zhao, Y., & Li, K. (2025). Optimization and Realization Path of Moral Education Flipped Classroom Teaching Model Based on Intelligent Computing in Colleges and Universities. *Journal of Combinatorial Mathematics and Combinatorial Computing*, *127a*, 8379–8396. https://doi.org/10.61091/jcmcc127a-462

Colque-Quispe, L. W., Sánchez-Aguirre, F. M., Arias-Camanera, J. A., Yucra-Choque, J. L., Correa-Vásquez, D., & Rodriguez-Barboza, J. R. (2025). Enhancing Autonomous Learning Through Flipped Classroom and Virtual Education: A Strategic Approach to SDG 4. *Multidisciplinary Science Journal*, *7*(12). https://doi.org/10.31893/multiscience.2025618

Eck, N. J. V, & Waltman, L. (2017). Citation-Based Clustering of Publications Using CitNetExplorer and VOSviewer. *Scientometrics*, *111*, 1053–1070.

Guo, L., Li, J., Xu, Z., Hu, X., Liu, C., Xing, X., Li, X., White, H., & Yang, K. (2024). The Relationship Between Homework Time and Academic Performance Among K-12: A Systematic Review. *Campbell Systematic Reviews*, *20*(3). https://doi.org/10.1002/cl2.1431

Hidayat, W. N., Oktaviani, A. T., Sutikno, T. A., Sari, R. K., Elmunsyah, H., & Sandy, T. A. (2019). Camlearn as Photography Mobile Learning Application and its Effects on Academic Achievement. *ICEEIE 2019 - International Conference on Electrical, Electronics and Information Engineering: Emerging Innovative Technology for Sustainable Future*, 168–171. https://doi.org/10.1109/ICEEIE47180.2019.8981467

Im, S. B., & Jakupov, G. A. (2025). The Use of Digital Educational Resources in Language Training for Transport Specialists. In *Lecture Notes in Networks and Systems* (Vol. 1366, pp. 193–199). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/978-3-031-88846-5_22

Kaspruk, N., Batranovska, S., Melnychuk, S., Unhuryan, T., Kopchuk, T., & Petryuk, A. (2025). Directions For Improving The Quality of Postgraduate Education of Physicians. *Neonatology, Surgery and Perinatal Medicine*, *15*(2), 28–32. https://doi.org/10.24061/2413-4260.XV.2.56.2025.4

Kay, R., Benzimra, D., & Li, J. (2017). Exploring Factors That Influence Technology-Based Distractions in Bring Your Own Device Classrooms. *Journal of Educational Computing Research*, *55*(7), 974–995. https://doi.org/10.1177/0735633117690004

Kunz, M., Schott, D., Wunderling, T., Halloul, M., Hansen, C., Albrecht, A., & Braun-Dullaeus, R. C. (2025). Embryonic Heart Development As an Immersive

Experience: Unveiling Learning Effects and Influential Factors in Virtual Learning Environments. *Computers in Biology and Medicine*, *187*. https://doi.org/10.1016/j.compbiomed.2024.109638

Li, J. (2021). Research on The Development and Operation of Pre-School Dance Online Course Based on "Internet." *ACM International Conference Proceeding Series*, 1458–1461. https://doi.org/10.1145/3456887.3459700

Li, J. (2022). Innovation of English Course Network Learning Model Based on Literature Data Mining Technology. *Lecture Notes on Data Engineering and Communications Technologies*, *84*, 842–849. https://doi.org/10.1007/978-981-16-5857-0_107

Liu, W., Hu, X., Bao, Z., Li, Y., Zhang, J., Yang, S., Huang, Y., Wang, R., Wu, J., Xu, X., Sang, Q., Di, W., Lu, H., Yin, X., & Qian, K. (2025). Serum Metabolic Fingerprints Encode Functional Biomarkers for Ovarian Cancer Diagnosis: A Large Scale Cohort Study. *EBioMedicine*, *115*. https://doi.org/10.1016/j.ebiom.2025.105706

Liu, Y., Wen, W., Gao, Y., Zhang, X., Qu, T., Yin, D., Peng, X., & Shi, Y. (2022). Online Homework Intelligent Platform Based on Self-Regulated Learning (SRL): Essential for Sustainable Development of Online Higher Education. *Sustainability (Switzerland)*, *14*(24). https://doi.org/10.3390/su142416904

Ngalomba, S., Mkwananzi, F., & Mukwambo, P. (2025). Internationalization at a Distance Via Virtual Mobility in the Global South: Advances and Challenges. *British Journal of Educational Technology*, *56*(2), 927–946. https://doi.org/10.1111/bjet.13557

Niu, S., Zhang, J., Lin, J., Wang, B., & Yan, J. (2025). Enhancing Anatomy Education with Virtual Reality: Integrating Three Dimensional Models for Improved Learning Efficiency and Student Satisfaction. *Frontiers in Medicine*, *12*. https://doi.org/10.3389/fmed.2025.1555053

Niu, W., Zhang, W., Zhang, C., & Chen, X. (2024). The Role of Artificial Intelligence Autonomy in Higher Education: A Uses and Gratification Perspective. *Sustainability (Switzerland)*, *16*(3). https://doi.org/10.3390/su16031276

Pandya, B., Cho, B., & Patterson, L. (2025). Impact of Digital Capabilities of Countries on the Pedagogical Transitions in Business Schools. *Global Knowledge, Memory And Communication*, *74*(5–6), 1826–1842. https://doi.org/10.1108/GKMC-06-2023-0201

Prasetia, I., Pasaribu, F., Arifin, M., Nasution, D. K., & Suprayetno, E. (2025). The Power of the Mobilizer Lecturer in the Independent Campus Program: An Exploration of Roles, Strategies, and Impact. *International Journal of Learning, Teaching and Educational Research*, *24*(6), 609–631. https://doi.org/10.26803/ijlter.24.6.28

Qin, S., Wu, W., Zheng, J., Wang, X., & Zhao, Y. (2017). An Optoelectric Professional's Training Model Based on Unity of Knowing And Doing Theory. In X. Liu & Z. X.-C. (Eds.), *Proceedings Of SPIE - The International Society for Optical Engineering* (Vol. 10452). SPIE. Https://Doi.Org/10.1117/12.2268549

Rajamäki, J., & Postolache, O. A. (2025). Considering The Ethics of AI-Based Technologies in Biomedical And Health Informatics (BMHI) Education. In M. E. Auer & T. Rüütmann (Eds.), *Lecture Notes in Networks And Systems: Vol. 1281 LNNS* (Pp. 176–184). Springer Science And Business Media Deutschland Gmbh. Https://Doi.Org/10.1007/978-3-031-83520-9_17

Sujannah, W. D., Suwarso, P. N., & Unsiah, F. (2025). The Correlation Between Chatgpt Use and Learning Autonomy Among ESP Students. *Cogent Education*, *12*(1). Https://Doi.Org/10.1080/2331186X.2025.2517508

Teng, Y., & Wang, X. (2021). The Effect of Two Educational Technology Tools on Student Engagement in Chinese EFL Courses. *International Journal of Educational Technology in Higher Education*, *18*(1). Https://Doi.Org/10.1186/S41239-021-00263-0

Uppal, K., & Hajian, S. (2025). Students' Perceptions of Chatgpt in Higher Education: A Study of Academic Enhancement, Procrastination, and Ethical Concerns. *European Journal of Educational Research*, *14*(1), 199–211. Https://Doi.Org/10.12973/Eu-Jer.14.1.199

Visser, M., Van Eck, N. J., & Waltman, L. (2021). Large-Scale Comparison of Bibliographic Data Sources: Scopus, Web Of Science, Dimensions, Crossref, and Microsoft Academic. *Quantitative Science Studies (QSS)*, *2*(1), 20–41.

Wang, X. (2016). Realization and Application of Multimedia Video System Based on Web Server in Teaching Of Engineering Measurement. *International Journal of Emerging Technologies in Learning*, *11*(5), 33–38. Https://doi.org/10.3991/ijet.v11i05.5691

Wang, X. (2022). Methods of Improving and Optimizing English Education in Colleges and Universities Assisted by Microvideo Technology. *Scientific Programming*, *2022*. https://doi.org/10.1155/2022/1291336

Wang, X. (2025). Evaluating Project Based Learning in Science and Technology Education: A Statistical Approach within Education Informatization Governance. *Proceedings of 2024 2nd International Conference on Information Education and Artificial Intelligence, ICIEAI 2024*, 278–284. https://doi.org/10.1145/3724504.3724550

Wittke, L., Hachem, P. E., Chen, Y., Ollier, J., Cheng, B., Gashi, S., & Zhang, X. (2025). Classifying Cognitive Load in Digital Textbook Reading Using

Electroencephalogram Signals. *2025 13th International Conference on Information and Education Technology, ICIET 2025*, 316–321. https://doi.org/10.1109/ICIET66371.2025.11045966

Yang, H., Liang, Z., Ma, M., Zhang, X., Fu, Y., & Zhang, Y. (2024). Study on Mode of Cultivating Computational Thinking in Online Teaching of Information Technology:A Quasi-Experimental Study. *ACM International Conference Proceeding Series*, 228–235. https://doi.org/10.1145/3670013.3670033

Yu, M., Xu, M., Liu, Z., Ying, Y., Weng, Q., O'Subhi, N., & Zhang, Y. (2023). Effectiveness of an Optional Breastfeeding Course for Multidisciplinary Undergraduate Healthcare Students: A Quasi Experimental Study. *Nurse Education in Practice*, *69*. https://doi.org/10.1016/j.nepr.2023.103609

Zhang, J., Chen, J., Guo, H., Liu, W., & Li, M. (2025). The Integrated Teaching Practice of Medical Cloud Dictionary Development and Project-based Learning. *BMC Medical Education*, *25*(1). https://doi.org/10.1186/s12909-024-06621-6

Zhang, P., Zhang, Y., Fan, S., Huang, X., & Zhang, J. (2019). Research and Implementation of Teaching System for Higher Vocational Specialty Courses based on Hybrid Teaching Mode. *Proceedings - 10th International Conference on Information Technology in Medicine and Education, ITME 2019*, 442–446. https://doi.org/10.1109/ITME.2019.00105

Zhang, X., Li, D., Wang, C., Jiang, Z., Ngao, A. I., Liu, D., Peters, M. A., & Tian, H. (2023). From ChatGPT to China' Sci-Tech: Implications for Chinese Higher Education. *Beijing International Review of Education*, *5*(3), 296–314. https://doi.org/10.1163/25902539-05030007

Zhang, X., & Lu, H. (2024). Optimization of Practical Path of Teaching Reform in Higher Education - Based on Distributed Logistic Model Application. *Applied Mathematics and Nonlinear Sciences*, *9*(1). https://doi.org/10.2478/amns-2024-1388

Zhang, Y. (2022). Analysis of O2O Teaching Assistant Mode of College English in MOOC Environment. *Journal of Environmental and Public Health*, *2022*. https://doi.org/10.1155/2022/8164934

Zhou, C., Ren, T., & Lang, L. (2025). The impact of AI-Based Adaptive Learning Technologies on Motivation and Engagement of Higher Education Students. *Education and Information Technologies*. https://doi.org/10.1007/s10639-025-13646-x