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Teachers' Digital Skills Research Trends: A Scopus Bibliometric Study (2020–2025)

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Abstract
The COVID-19 pandemic has catalyzed fundamental changes in educational technology integration, emphasizing the critical importance of teachers' digital competencies beyond emergency remote teaching. This study presents a comprehensive bibliometric analysis of research trends in teachers' digital skills using Scopus-indexed publications from 2020 to 2025. Through systematic document retrieval and screening, we analyzed 1,129 relevant publications using Biblioshiny (R-bibliometrix) and VOSviewer to examine publication patterns, collaboration networks, and conceptual evolution. The findings reveal a significant increase in scientific productivity, with a compound annual growth rate of 14.94%, alongside substantial international collaboration, as 16.14% of the publications involved co-authorship across multiple countries. Thematic analysis identified four major research clusters: digital competency frameworks, pedagogical integration strategies, professional development models, and emerging technological innovations. The intellectual structure indicates a shift from crisis-response studies toward more systematic approaches to digital skill development, with artificial intelligence emerging as a prominent research frontier. Overall, this study maps the evolving landscape of teachers' digital skills research and highlights key publication patterns, thematic shifts, and emerging trends that shape the field in the post-pandemic era.
***Keywords:** bibliometric analysis; digital competence; digital skills; teacher education; TPACK*

Abstrak
Pandemi COVID-19 telah memicu perubahan mendasar dalam integrasi teknologi pendidikan, sekaligus menegaskan pentingnya kompetensi digital guru yang melampaui konteks pembelajaran jarak jauh darurat. Penelitian ini menyajikan analisis bibliometrik komprehensif terhadap tren riset mengenai keterampilan digital guru berdasarkan publikasi terindeks Scopus pada periode 2020–2025. Melalui proses penelusuran dan penyaringan dokumen secara sistematis, sebanyak 1.129 publikasi yang relevan dianalisis menggunakan Biblioshiny (R-bibliometrix) dan VOSviewer untuk mengkaji pola publikasi, jaringan kolaborasi, serta evolusi konseptual penelitian. Hasil analisis menunjukkan peningkatan signifikan dalam produktivitas ilmiah dengan tingkat pertumbuhan tahunan majemuk sebesar 14,94%, disertai kolaborasi internasional yang cukup kuat, di mana 16,14% publikasi melibatkan penulis dari lebih dari satu negara. Analisis tematik mengidentifikasi empat klaster penelitian utama, yaitu kerangka kompetensi digital, strategi integrasi pedagogis, model pengembangan profesional, dan inovasi teknologi yang sedang berkembang. Struktur intelektual bidang ini menunjukkan pergeseran dari studi yang bersifat respons krisis menuju pendekatan yang lebih sistematis dalam pengembangan keterampilan digital guru, dengan kecerdasan buatan muncul sebagai salah satu frontier penelitian yang menonjol. Secara keseluruhan, penelitian ini memetakan lanskap

perkembangan riset keterampilan digital guru serta menyoroti pola publikasi, pergeseran tematik, dan tren baru yang membentuk bidang ini pada era pascapandemi.
Kata Kunic: *bibliometrik; kompetensi digital; keterampilan digital; pendidikan guru; TPACK*

Introduction

Teachers' digital skills have become a strategic issue in academic research and educational policy development (Fessl et al., 2023; Momdjian et al., 2025; Dolezal et al., 2025). Conceptually, this competence is understood as a multidimensional construct encompassing technical, pedagogical, ethical, and critical aspects, which continuously evolves in response to the increasing complexity of digital education demands (Turpo-Gebera et al., 2025; Joshi et al., 2021; Nagel & Amdam, 2025; Sari & Sangka, 2023). Various frameworks have been employed to conceptualize and measure teachers' digital competence, with TPACK and DigCompEdu serving as the primary references, each offering distinct strengths and limitations in guiding and assessing digital competence (Bećirović, 2023; Svoboda, 2024; Papic et al., 2022; Sari & Sangka, 2023). DigCompEdu emphasizes professional engagement, the use of digital resources, teaching and learning management and assessment, learner empowerment, and the facilitation of students' digital competence (Gümüş & Kukul, 2023), whereas TPACK highlights the intersection of technological, pedagogical, and content knowledge as the foundation for meaningful technology integration (Canbazoglu Bilici et al., 2025). Recent developments are also marked by the emergence of AI-based models such as AI-PACK and intelligent-TPACK, which respond to the growing need for AI literacy, digital security, and ethical responsibility in education (Baskara, 2025; Ismail et al., 2025).

The strengthening of teachers' digital skills is influenced by structural and contextual factors, including access to ICT infrastructure, institutional readiness, policy support, and individual teacher characteristics such as age, teaching experience, and technological self-efficacy (Sánchez et al., 2020; Chen et al., 2026). Disparities across regions, countries, and types of institutions result in uneven development of digital competence (Ngoveni et al., 2025; Estrada-Araoz et al., 2024), while internal factors such as workload, technological self-efficacy, and resistance to change affect the effectiveness of digital transformation in education (Rotary-Saban & Shonfeld, 2025; Farren et al., 2025; Canbazoglu Bilici et al., 2025). These conditions highlight the need for a

comprehensive scientific mapping, as scholarly publications function not only as indicators of academic productivity but also as a means to understand the direction, dynamics, and evolution of research on teachers' digital skills (Bayu et al., 2026).

Bibliometric analysis is an effective approach for mapping publication trends, researcher contributions, and the dynamics and impact of research within a specific field (Donthu et al., 2021). Although several bibliometric studies have been conducted (Table 1), research that specifically and comprehensively maps teachers' digital skills, particularly in the post-pandemic context, remains relatively limited. By employing bibliometric analysis, the development and dynamics of research on teachers' digital skills can be assessed more systematically, including how this topic evolved during the pandemic and shifted into the post-pandemic phase.

Table 1. Previous Studies on Bibliometric Analysis of Digital Skills

No	Title	Key Findings
1	Analyzing trends in online learning in higher education in the BRICS countries through bibliometric data (Orekhovskaya et al., 2024)	Publications on online learning in BRICS countries increased in the post-pandemic period, with two main focuses: e-learning and COVID-19, and uneven patterns of collaboration across countries.
2	Bibliometric analysis and systematic review of digital competence in education (Ma & Ismail, 2025)	The bibliometric-SLR study identifies core themes of digital competence and highlights measurement challenges and the need to integrate digital competence into education systems.
3	Knowledge mapping of research on teachers' digital competence in China: a bibliometric analysis using CiteSpace (Li & Tinmaz, 2025)	Research on teachers' digital competence in China shows an increasing trend, focusing on teacher training, measurement models, and emerging frontiers related to artificial intelligence.
4	Digital literacy for higher students: A bibliometric analysis from 1978 to 2023 (Hung et al., 2025)	Research on students' digital literacy has increased sharply since 2016, reinforced by the pandemic, with major issues related to e-learning and the digital divide.
5	COVID-19 and teachers' digital competencies: a comprehensive bibliometric and topic modeling analysis (Gökdaş et al., 2024a)	Publications on teachers' digital competence increased significantly during the pandemic, with dominant themes on teacher training and pedagogical technology integration.
6	A Bibliometric Analysis and Visualisation of Digital Teaching and Learning Publications From Southeast Asia Countries (Nguyen et al., 2024)	Research on digital teaching and learning in Southeast Asia surged during 2019–2023, dominated by e-learning and COVID-19 topics, with still-limited international collaboration.

Research on digital learning and digital competencies/literacies has grown rapidly (Table 1). However, previous bibliometric studies have tended to be broad, addressing general digital competencies or technology integration, or have been limited to specific contexts and regions. Few studies have treated teachers' digital skills as a distinct domain and systematically mapped its publication dynamics, collaboration structures, and thematic evolution. This study conducted a Scopus-based bibliometric mapping of teachers' digital skills research (2020–2025) to clarify the structure of the field and identify emerging research trends.

This study is designed to address three main focuses: (1) the quality of the dataset and the characteristics of publications on teachers' digital skills during the 2020–2025 period; (2) trends in research productivity, sources, and actors, including annual publication growth, the most influential sources and documents, authors, affiliations, countries, as well as collaboration patterns and citation impact; and (3) the conceptual structure and thematic evolution of the research, analyzed through keyword co-occurrence, thematic mapping, bibliographic coupling, and topic trends in the post-pandemic era. Through these three focuses, the study is expected to provide a comprehensive mapping of the scholarly landscape on teachers' digital skills, while also offering an empirical foundation for the development of future research agendas and the formulation of more effective policies to strengthen teachers' digital competence in the post-pandemic era.

Research Method

This study employs bibliometric analysis to map the scholarly landscape of research on teachers' digital skills in Scopus-indexed publications from 2020 to 2025. The analytical indicators include publication productivity, citation impact, source characteristics, scientific collaboration, and the conceptual structure of the research field. The research subjects consist of scholarly documents retrieved from the Scopus database, while the research instruments include the Scopus database and analytical software, namely Biblioshiny (R-bibliometrix) and VOSviewer, which were used for data analysis and visualization. The stages of the research process are presented in Figure 1.

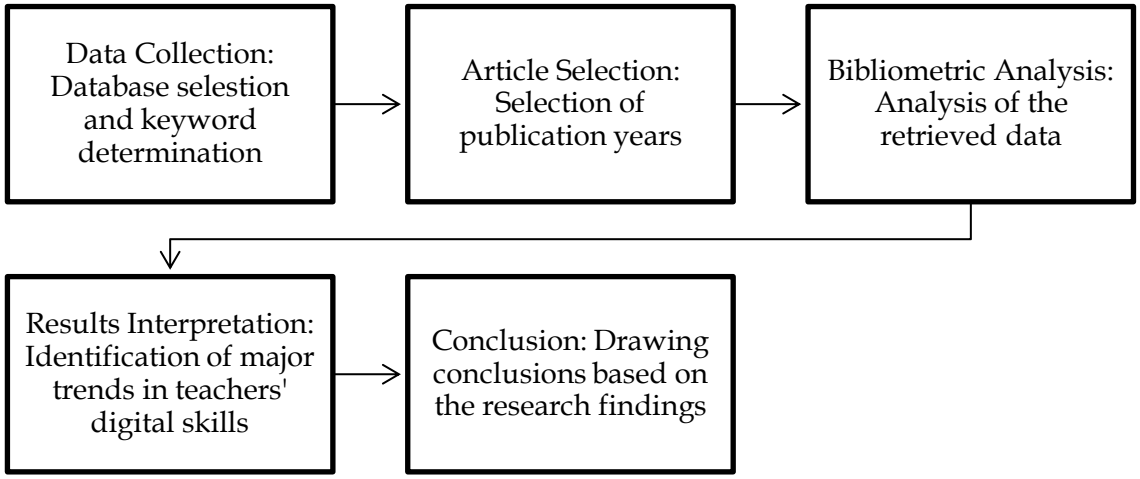

Figure 1. Research Stages

Data Collection

Data were collected from the Scopus database. The search strategy was defined using a query applied to the title, abstract, and keyword fields, as follows: (TITLE-ABS-KEY ("digital skill*") AND TITLE-ABS-KEY (teacher*)) AND PUBYEAR > 2019 AND PUBYEAR < 2026. The search was conducted on December 2, 2025, to retrieve publications published between 2020 and 2025. All metadata obtained from the search results were downloaded from Scopus in formats compatible with Biblioshiny and VOSviewer. The metadata included information on authors, affiliations, publication years, sources, abstracts, keywords, references, and citation data.

Article Selection

Document selection ensured corpus relevance and replicability. Scopus was used as the sole data source due to its broad coverage of peer-reviewed literature and standardized, high-quality metadata suitable for bibliometric and network analyses. Inclusion criteria were: (1) publications from 2020–2025; (2) topics aligned with the search query on teachers' digital skills; and (3) documents indexed in Scopus at the time of data collection. Exclusion criteria covered irrelevant documents and duplicates. Data from 2025 were interpreted cautiously due to potential indexing delays that may affect publication and citation counts.

Bibliometric Analysis

Bibliometric analysis was conducted using Biblioshiny and VOSviewer to cover both performance analysis and science mapping. Biblioshiny was used to generate quantitative indicators such as annual publication trends, document type distribution, most relevant sources, author-, affiliation-, and country-level productivity, citation analysis (including most globally cited documents and average citations per year), and collaboration metrics. VOSviewer was employed to construct and visualize scholarly networks. The analytical parameters focused on outputs directly aligned with the research objectives, including trends, dominant actors, influential sources, collaboration patterns, and the temporal dynamics of research themes.

Results Interpretation

The interpretation stage involved synthesizing bibliometric outputs and network visualizations to identify major patterns in research on teachers' digital skills, including: (1) publication growth trajectories; (2) concentration of influential sources and research actors; (3) the intensity and characteristics of international collaboration; and (4) the conceptual structure of the field and the evolution of research themes during the 2020–2025 period. The results were analyzed using a descriptive-analytical approach that integrated quantitative indicators and network maps to derive conclusions regarding the development of the field, thematic trends, and opportunities for future research. The final stage of the study involved drawing conclusions based on the overall findings of the bibliometric analysis.

Results and Discussion

Dataset Quality and Publication Characteristics

Research on teachers' digital skills has shown a significant increase, particularly during the COVID-19 pandemic, reflecting the urgent need for digital competencies in education (Juliandarini et al., 2024; Ohle-Peters & Shahat, 2023). An assessment of data quality was conducted on all Scopus search results, comprising 1,129 documents (Table 2). Meanwhile, the summary of the main information and the analysis of publication characteristics in this subsection were based on a subset of 818 documents published between 2021 and 2024 (Table 3).

The metadata completeness assessment indicates that the core elements required for bibliometric analysis—abstract (AB), document type (DT), language (LA),

publication year (PY), title (TI), and total citations (TC)—were fully available (0% missing) and classified as *Excellent*. Supporting elements such as authors (AU), affiliations (C1), cited references (CR), and authors' keywords (DE) showed low levels of incompleteness (1.42%–8.68%) and were therefore categorized as *Good*. In contrast, the digital object identifier (DOI; DI) and source title (SO) exhibited moderate levels of incompleteness (11.16% and 12.84%, respectively) and were classified as *Acceptable*. This completeness profile indicates that the core variables are very well documented and sufficient for mapping research trends, citation patterns, and conceptual structures. However, the moderate incompleteness of DOI and source title should be considered in subsequent analyses that rely on document identity normalization.

Table 2. Metadata Completeness

Metadata	Description	Missing Counts	Missing %	Status
AB	Abstract	0	0.00%	Excellent
DT	Document Type	0	0.00%	Excellent
LA	Language	0	0.00%	Excellent
PY	Publication Year	0	0.00%	Excellent
TI	Title	0	0.00%	Excellent
TC	Total Citation	0	0.00%	Excellent
AU	Author	16	1.42%	Good
C1	Affiliation	19	1.68%	Good
CR	Cited References	23	2.04%	Good
DE	Keywords	98	8.68%	Good
DI	DOI	126	11.16%	Acceptable
SO	Journal	145	12.84%	Acceptable

In the analytical subset (Table 3), the dataset comprises 818 documents distributed across 349 sources, with an annual growth rate of 14.94% and an average document age of 2.32 years, indicating a relatively young and rapidly expanding body of literature. Scholarly impact is reflected in an average of 8.493 citations per document and 6,586 cited references, suggesting an active citation network within the field. In terms of content, the dataset includes 2,093 authors' keywords (DE) and 1,421 Keywords Plus (ID), indicating considerable thematic breadth and providing a strong basis for conceptual clustering analysis.

Collaboration characteristics involve 2,383 authors, with 124 single-authored documents, an average of 3.28 authors per document, and 16.14% international co-authorship, reflecting a predominantly collaborative knowledge production pattern

while still leaving room for strengthening cross-national research networks. The composition of document types is dominated by journal articles (521), followed by conference papers (182) and book chapters (75), underscoring that scholarly dissemination in this field primarily occurs through peer-reviewed journals, with conference proceedings serving as an important channel for more rapid dissemination of research findings.

Table 3. Main Information

Description	Result
Main Information About Data	
Timespan	2021:2024
Sources (Journals, Books, etc)	349
Documents	818
Annual Growth Rate %	14.94
Document Average Age	2.32
Average citations per doc	8.493
References	6586
Document Contents	
Keywords Plus (ID)	1421
Author's Keywords (DE)	2093
AUTHORS	
Authors	2383
Authors of single-authored docs	110
Authors Collaboration	
Single-authored docs	124
Co-Authors per Doc	3.28
International co-authorships %	16.14
Document Types	
article	521
book	4
book chapter	75
conference paper	182
conference review	10
data paper	1
editorial	2
note	1
review	22

The high quality of metadata in the core elements, combined with publication characteristics dominated by journal articles, a relatively strong level of collaboration, and a wide diversity of keywords, provides a solid methodological foundation for further bibliometric analysis. Building on this dataset foundation, the following

subsection presents patterns of annual productivity growth, the concentration of publication sources, and the distribution of research actors (authors, affiliations, and countries) that shape the research landscape of teachers' digital skills during the observed period.

Trends in Research Productivity, Sources, and Research Actors

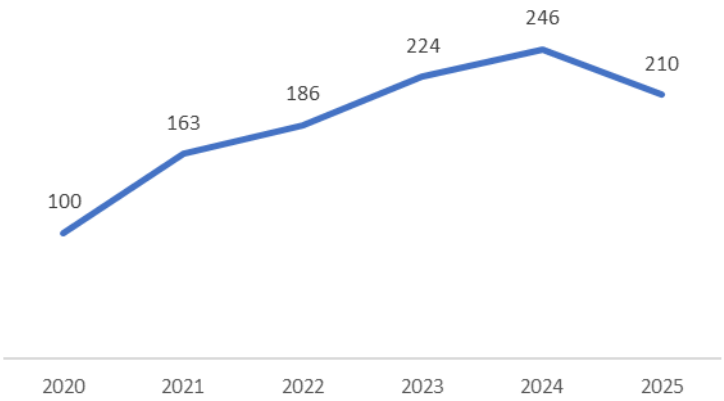

Figure 2. Annual Scientific Production

Overall, publication dynamics indicate a strengthening of research on teachers' digital skills from the pandemic phase to the post-pandemic phase, with contributions concentrated in a limited number of core publication outlets as well as among specific groups of authors and countries. As shown in Figure 2, the number of publications increased consistently from 2020 to 2024 and reached a peak in 2024, while the lower count recorded for 2025 should be interpreted with caution, as the year is still ongoing. This pattern reinforces the view that research on teachers' digital skills expanded rapidly during the pandemic and has continued to develop as a more established research agenda in the post-pandemic period.

Figure 3 (three-field plot) further highlights the interconnections among key references, productive authors, and dominant keywords, illustrating the role of digital competence frameworks—such as DigCompEdu and related models—as conceptual anchors guiding themes including digital skills, digital competence, teacher training, e-learning, students, and teaching. Variations in terminology primarily reflect differences in implementation contexts, such as teacher training, online learning, and instructional practices, without undermining the consistency of the underlying theoretical foundations.

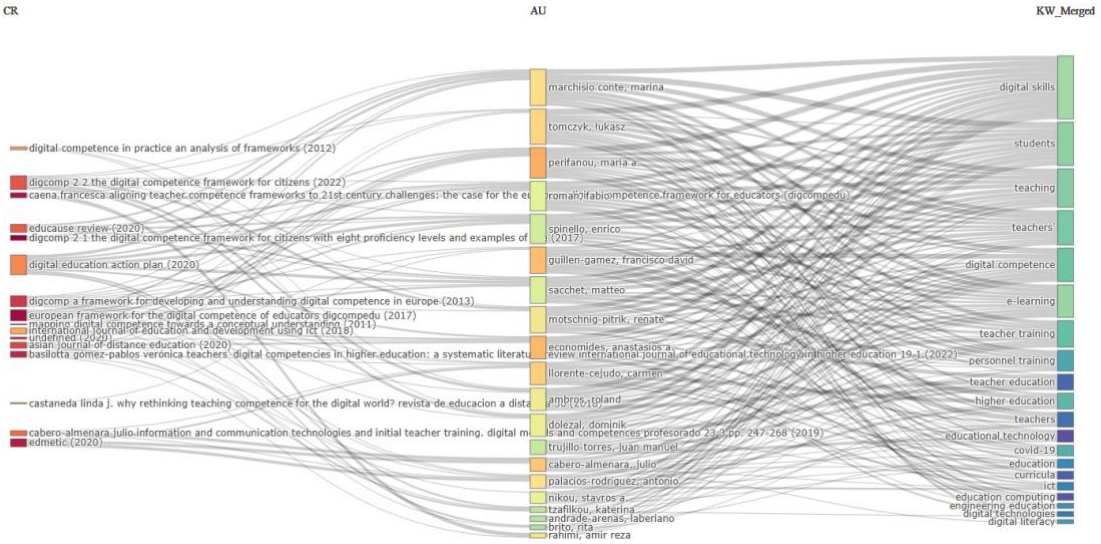

Figure 3. Three-Field Plot (CR–AU–KW)

From the perspective of dissemination channels, Figure 4 reveals the presence of core sources that play a dual role—as the most productive outlets while also exerting strong local impact within the corpus—thereby forming central hubs of scholarly dissemination and reference in this field. The dominance of journals and conference proceedings closely related to educational technology underscores the interdisciplinary nature of research on teachers' digital skills, situated at the intersection of pedagogy and learning technologies. This pattern is consistent with the broader literature that positions teachers' digital skills as a strategic issue in the innovation of teaching practices (Fernández-Otoya et al., 2024; Juliandarini et al., 2024).

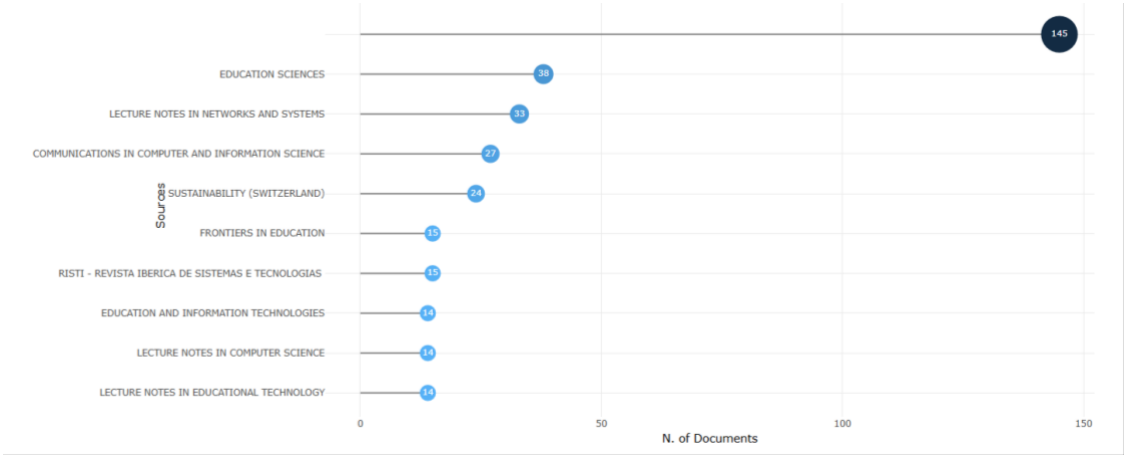

Figure 4. Most Relevant Sources

Consistent with these findings, Figure 5 presents the distribution of subject areas, positioning the social sciences–education cluster as the primary foundation, with strong

contributions from computer science and engineering. This composition indicates that the development of teachers' digital skills is grounded in multidisciplinary approaches that integrate education, digital systems, and the engineering of learning technologies.

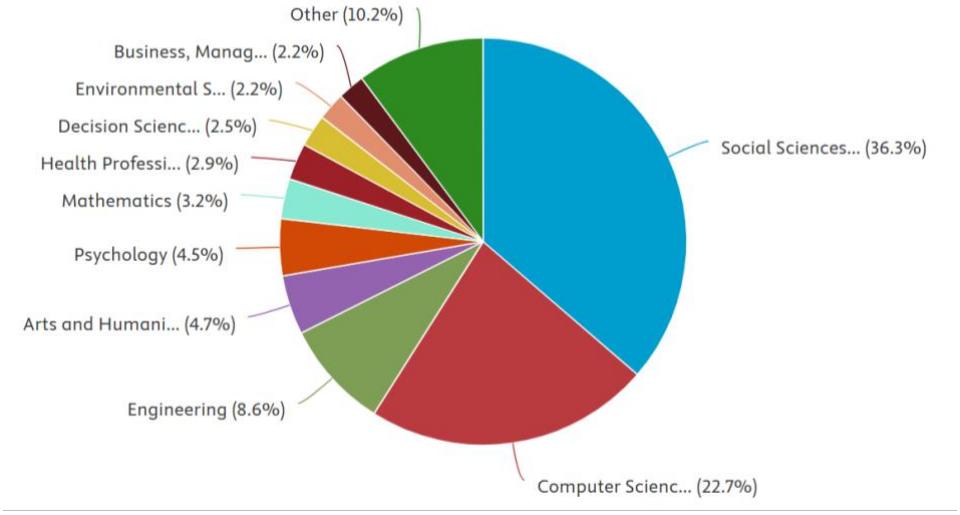

Figure 5. Documents by Subject Area

At the actor level, Figure 6 identifies the most productive authors who serve as key drivers of knowledge production in this field. The most productive author is Perifanou, M. (14 documents), followed by Economides, A.A. (12) and Guillén-Gámez, F.D. (10), then Tomczyk, Ł. (9) and Rdhimi, A.R. (8). Other authors with stable contributions include Cabero-Almenara, J., Motschnig, R., and Palacios-Rodríguez, A. (7 documents each), as well as Ambros, R. (6 documents).

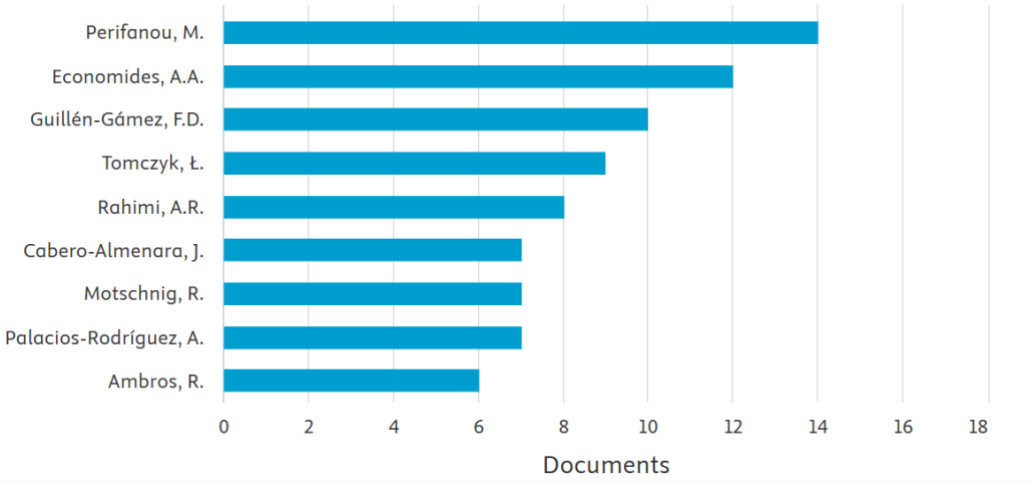

Figure 6. Most Productive Author

Meanwhile, Figure 7 shows the concentration of corresponding authors' countries in a limited number of dominant countries, alongside variations in cross-national

collaborative publications (single-country publications vs. multiple-country publications). Spain emerges as the most dominant contributor, followed by Italy, and then a group of other countries such as Portugal, Peru, and Germany, with additional participation from China and Indonesia. This pattern suggests that international research networks have begun to form, although collaboration intensity remains uneven, leaving substantial opportunities to strengthen global collaboration, including greater involvement from underrepresented regions.

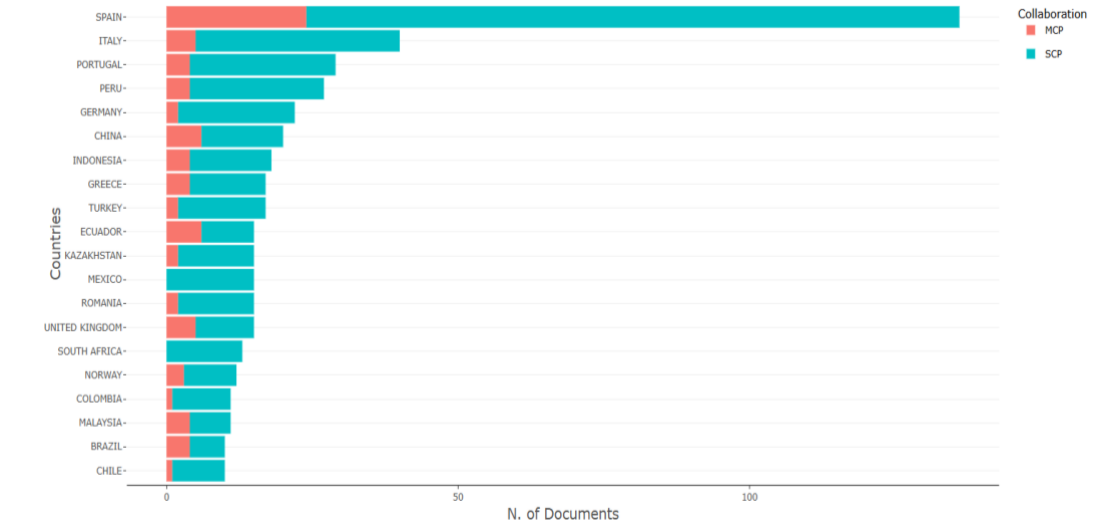

Figure 7. Corresponding Author's Countries

Research on teachers' digital skills has grown rapidly and become increasingly structured, characterized by clearly defined dissemination centers (core sources), dominant actors and countries shaping scholarly production, and a multidisciplinary foundation that provides the basis for examining the conceptual structure and thematic evolution discussed in the following subsection.

Conceptual Structure and Thematic Evolution of Research

The keyword co-occurrence network analysis (Figure 8) positions digital skills as the most central conceptual node in the research landscape on teachers' digital skills during 2020–2025. Its strong connections with the keywords teachers, students, and e-learning form a core structure that links educational actors to digital learning contexts, while also reflecting a dominant cluster centered on teacher training, digital competence development, and the integration of ICT- and educational-technology-based learning. This structure is reinforced by the density visualization, which shows the highest

concentration around digital skills, teaching, and e-learning, confirming the dominance of these themes in post-pandemic scholarly discourse.

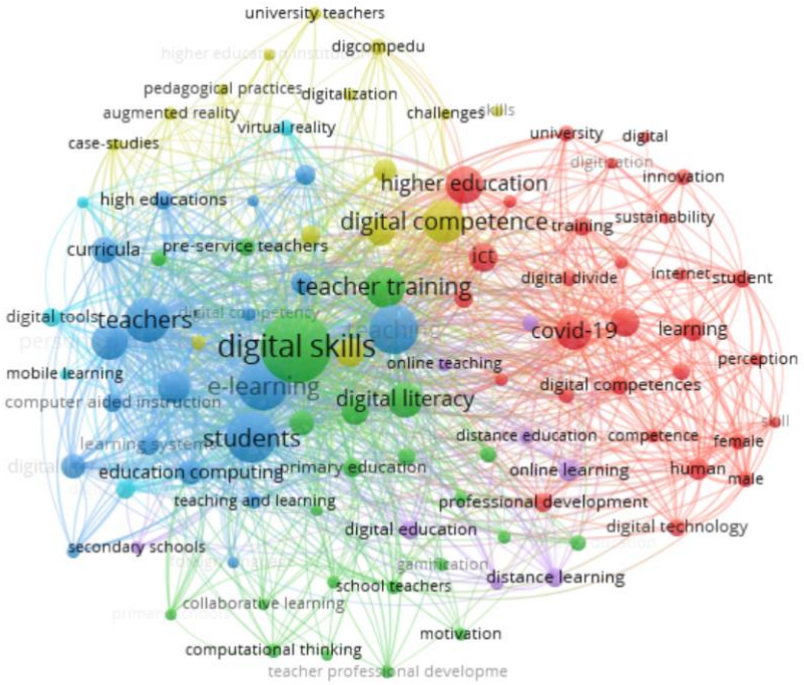

Figure 8. VOSviewer Visualization

The thematic map (Figure 9) further clarifies the position and maturity of themes. The digital skills–e-learning–students cluster is located in the *basic themes* quadrant, highlighting its role as a foundational and highly relevant research area that continues to expand. The theme cluster education–learning–teacher appears as more mature and stable. Meanwhile, themes such as 21st-century digital competence and artificial intelligence in education emerge as *niche themes*—conceptually dense and specialized, yet still relatively limited in their linkage to the core themes. This configuration indicates that research on teachers' digital skills has progressed beyond technology adoption toward more complex emphases on competence development, pedagogy, and training design.

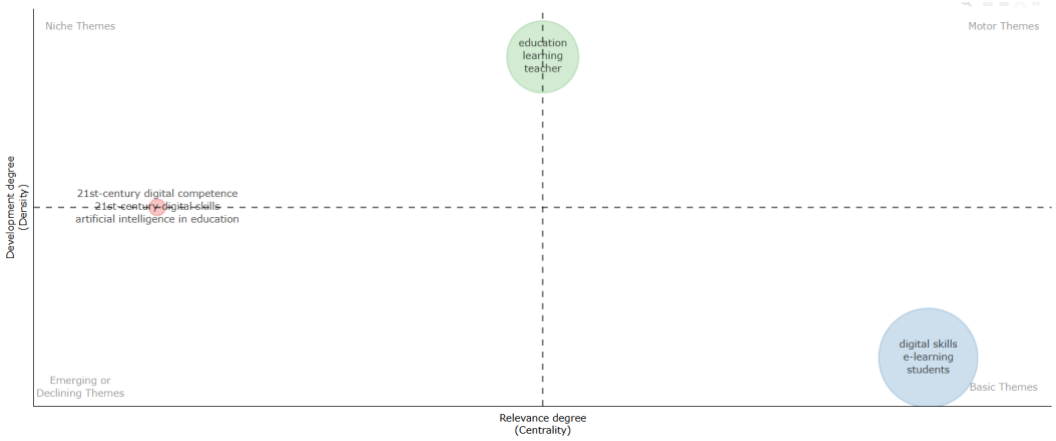

Figure 9. Thematic Map

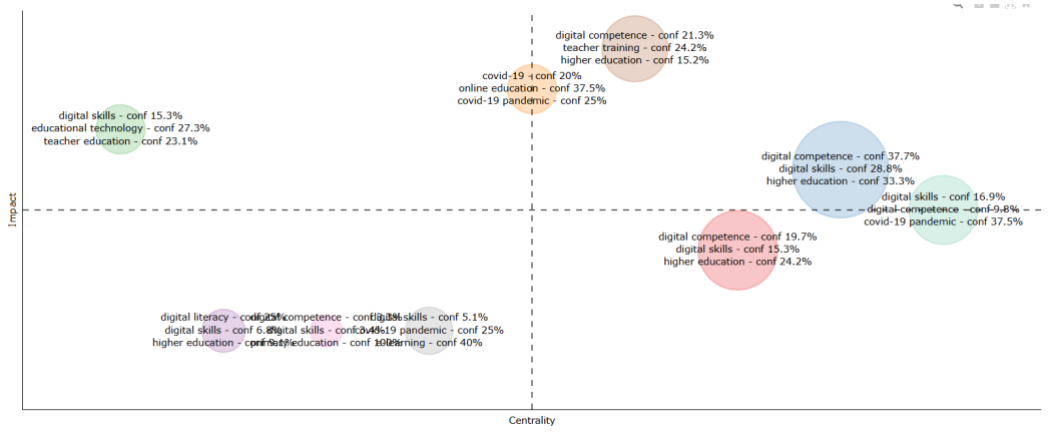

Figure 10. Bibliographic Coupling

Bibliographic coupling results (Figure 10) show theme clustering based on reference proximity and impact strength, with influential clusters highlighted around digital competence, digital skills, higher education, and COVID-19. This structure affirms the pandemic as a catalyst that expanded scholarly attention and output on teachers' digital competence, while also indicating the consolidation of a post-pandemic agenda oriented toward capacity building through teacher education, professional development, and more systematic technology integration. Supporting themes such as digital literacy and educational technology function as conceptual bridges that enrich the main structure of the field.

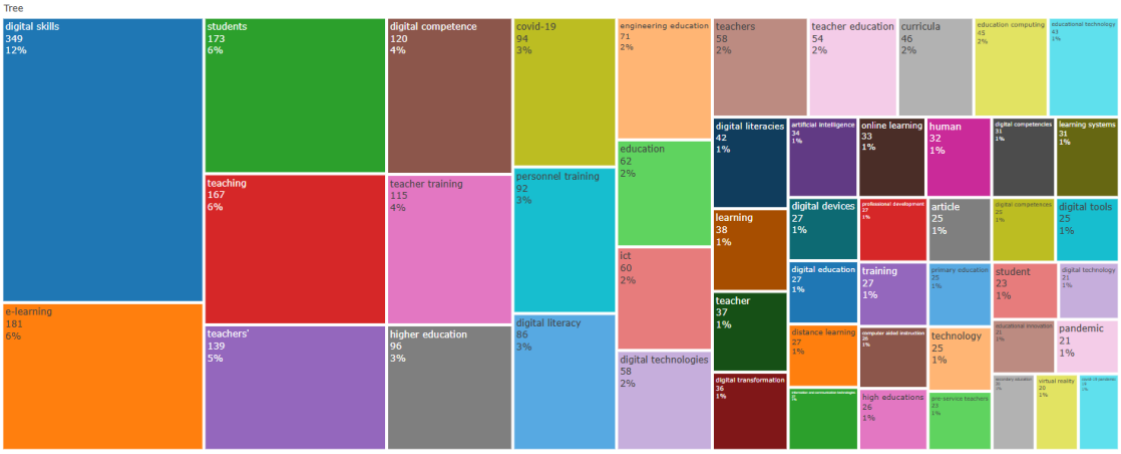

Figure 11. Tree Map

In line with these findings, the tree map (Figure 11) confirms the dominance of digital skills as the largest theme, followed by e-learning, students, and teaching, along with the consistent presence of terms such as teachers, teacher training, digital competence, and higher education. The continued appearance of COVID-19, digital literacy, ICT, and digital technologies indicates the lasting imprint of pandemic-era educational transformation on post-pandemic research orientations. Trend topics analysis (Figure 11) strengthens this evolutionary pattern: early stages were dominated by COVID-19, e-learning, and ICT (emergency adaptation), followed by a shift toward more pedagogical and competence-based themes such as digital skills, teachers, and students. In the most recent period, research has increasingly emphasized teacher education, technology integration, and TPACK, signaling the institutionalization of technology integration within teachers' professional development.

Within a broader conceptual framework, these bibliometric findings align with literature that positions TPACK as the foundation for integrating technology, pedagogy, and content, and SAMR as a model describing stages of technology integration from substitution to redefinition (Bećirović, 2023). DigCompEdu and ICT-CFT strengthen competence-based approaches through standardized structures, personalized training pathways, and policy–curriculum perspectives in teaching practice (Cabero-Almenara et al., 2021). Conceptually, teachers' digital skills can also be interpreted through three interconnected dimensions—computer literacy, digital literacy, and digital competence—forming a holistic framework for understanding the evolution of digital competence in education (Santos & Gomes, 2024).

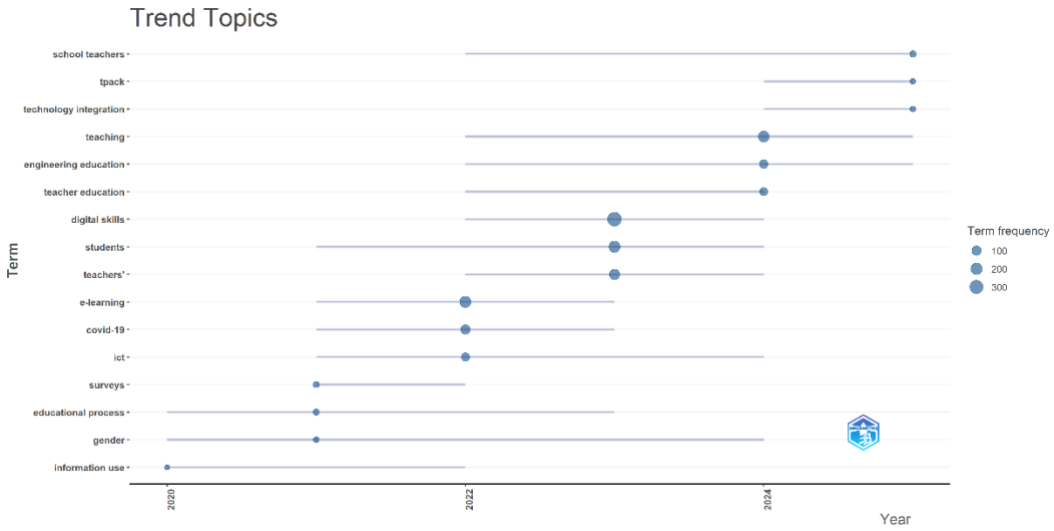

Figure 12. Trend Topics

The literature shows developmental stages consistent with the topic map findings: an initial focus on strengthening basic digital skills (C. Liu & Xu, 2025), a shift toward deeper technology integration into pedagogical strategies during the pandemic (Gökdaş et al., 2024b), and a more recent emphasis on competence-based approaches through systematic reforms to improve digital literacy standards and sustainable technology integration strategies (Zhang et al., 2025). Research directions highlight the importance of continuous professional development (Manowaluilou et al., 2024), attention to digital access equity (C. Liu & Xu, 2025), and the strengthening of learning innovation, including in STEM contexts that require digital competence for creativity and problem-solving (Spyropoulou et al., 2024). Looking ahead, policy coordination and cross-disciplinary collaboration are critical to reducing digital divides (X. Liu et al., 2025), alongside the development of personalized training programs grounded in validated frameworks to ensure more effective and sustainable integration of digital skills (Cabero-Almenara et al., 2021; Rahimi & Daneshvar Ghorbani, 2025).

The conceptual structure and thematic evolution reveal a transition from situational responses during the pandemic toward long-term capacity building, with teachers' digital skills serving as the central axis connecting pedagogy, technology, and learning contexts. These findings also open avenues for further research to integrate more specific themes, particularly artificial intelligence and learning analytics, into the mainstream development of teachers' digital competence, thereby strengthening both theoretical contributions and post-pandemic educational practice.

Conclusion

This bibliometric study mapped the research landscape on teachers' digital skills in Scopus-indexed publications from 2020 to 2025. The results show a consistent increase in publication output and a thematic shift from crisis-response discussions of ICT and emergency remote teaching toward more systematic themes, particularly digital competence frameworks, teacher education, and pedagogical technology integration. The analysis identified four dominant research clusters—digital competency frameworks, pedagogical integration strategies, professional development models, and emerging technological innovations—revealing how scholarly attention has evolved during the post-pandemic period. International collaboration was also evident, with 16.14% of publications involving cross-country co-authorship, indicating a growing global research network, while artificial intelligence emerged as a prominent research frontier in the field. This study is limited by its reliance on a single database (Scopus) and by the nature of bibliometric approaches, which emphasize patterns and structures of the literature rather than evaluating the empirical quality of individual studies. Future research may expand data sources, integrate bibliometric mapping with systematic reviews, and conduct empirical investigations to examine how the identified themes and AI-related trends are implemented across educational contexts.

References

Baskara, F. X. R. (2025). Conceptualizing Digital Literacy for the AI Era: A Framework for Preparing Students in an AI-Driven World. *Data and Metadata*, *4*. https://doi.org/10.56294/dm2025530

Bayu, A., Nandiyanto, D., Novia, D., & Husaeni, A. (2026). Trend in Publication in Chemical Engineering in Indonesia : A Bibliometric Analysis Perspective Relating to Particle Technology. *Journal of Advanced Research Design*, *144*(1), 21–42.

Bećirović, S. (2023). Fostering Digital Competence in Teachers: A Review of Existing Frameworks. In *Springer Briefs in Education* (pp. 51–67). Springer Science and Business Media B.V. https://doi.org/10.1007/978-981-99-0444-0_5

Cabero-Almenara, J., Gutiérrez-Castillo, J. J., Palacios-Rodríguez, A., & Barroso-Osuna, J. (2021). Comparative European digcompedu framework (JRC) and common framework for teaching digital competence (INTEF) through expert judgment. *Texto Livre*, *14*(1). https://doi.org/10.35699/1983-3652.2021.25740

Canbazoglu Bilici, S., Şentürk, M., Kizilay, E., Yildiz Durak, H., & Sancar Tokmak, H. (2025). SQD strategies integrated online TPACK-based professional development: Examining science teachers' TPACK practical and self-efficacy. *Research in Science and Technological Education*, *43*(4), 1352–1381. https://doi.org/10.1080/02635143.2024.2440400

Chen, C.-H., Fei, H.-Y., & Tsai, C.-C. (2026). Hierarchical analysis of in-service teachers' barriers to technology-integrated instruction: A review of 2000–2024 publications.

Computers and Education, *242*. https://doi.org/10.1016/j.compedu.2025.105509

Dolezal, D., Motschnig, R., & Ambros, R. (2025). Pre-Service Teachers' Digital Competence: A Call for Action. *Education Sciences*, *15*(2). https://doi.org/10.3390/educsci15020160

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Marc, W. (2021). How to conduct a bibliometric analysis : An overview and guidelines. *Journal of Business Research*, *133*(March), 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Estrada-Araoz, E. G., Larico-Uchamaco, G. R., Jara-Rodríguez, F., & Pachacutec-Quispicho, R. (2024). Assessment of digital competencies in basic education teachers: A descriptive study. *Salud, Ciencia y Tecnologia - Serie de Conferencias*, *3*. https://doi.org/10.56294/sctconf2024632

Farren, M. A., Crotty, Y. P., Manley, S. J., & Chaniotakis, E. (2025). From zoom to bloom: Developing the self-efficacy of physics teachers through collaborative online professional development. In *Navigating the Global Workforce Through Bold Workplace Learning and Professional Development* (pp. 85–110). IGI Global. https://doi.org/10.4018/979-8-3693-3338-9.ch004

Fernández-Otoya, F., Cabero-Almenara, J., Pérez-Postigo, G., Bravo, J., Alcázar-Holguin, M. A., & Vilca-Rodríguez, M. (2024). Digital and Information Literacy in Basic-Education Teachers: A Systematic Literature Review. *Education Sciences*, *14*(2). https://doi.org/10.3390/educsci14020127

Fessl, A., Divitini, M., & Maitz, K. (2023). Transferring Digital Competences for Teaching from Theory into Practice Through Reflection. In V. O., J. I., M.-M. P.J., P. M., & P. T. (Eds.), *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics): Vol. 14200 LNCS* (pp. 554–559). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/978-3-031-42682-7_41

Gökdaş, İ., Karacaoğlu, Ö. C., & Özkaya, A. (2024a). COVID-19 and teachers' digital competencies: a comprehensive bibliometric and topic modeling analysis. *Humanities and Social Sciences Communications*, *11*(1140), 1–17. https://doi.org/10.1057/s41599-024-04335-0

Gökdaş, İ., Karacaoğlu, Ö. C., & Özkaya, A. (2024b). COVID-19 and teachers' digital competencies: a comprehensive bibliometric and topic modeling analysis. *Humanities and Social Sciences Communications*, *11*(1). https://doi.org/10.1057/s41599-024-04335-0

Gümüş, M. M., & Kukul, V. (2023). Developing a digital competence scale for teachers: validity and reliability study. *Education and Information Technologies*, *28*(3), 2747–2765. https://doi.org/10.1007/s10639-022-11213-2

Hung, D. V, Long, D. T., Tuyet, B. T. A., Mai, N. H., Yen, T. T. H., Van, V. T. H., & Hai, N. T. (2025). Digital literacy for higher students: A bibliometric analysis from 1978 to 2023. *College and Undergraduate Libraries*, *32*(3–4), 103–132. https://doi.org/10.1080/10691316.2025.2550935

Ismail, A., Ana, A., Muktiarni, M., Sulaiman, J., Punyayodhin, S., & Feizi, A. (2025). Bridging The Digital Divide: A Comparative Study of Digital Competencies Among TVET Teachers in TVET Institutions in Asian Countries. *Journal of Technical Education and Training*, *17*(3), 79–91. https://doi.org/10.30880/jtet.2025.17.03.006

Joshi, D. R., Neupane, U., & Joshi, P. R. (2021). Synthesis review of digital frameworks and DEPSWALIC Digital competency framework for teachers from basic to University Level. *Mathematics Teaching-Research Journal*, *13*(2), 108–136. https://www.scopus.com/inward/record.uri?eid=2-s2.0-

85110254352&partnerID=40&md5=568355abef2f60e9f2d3ec64c430261c

Juliandarini, J., Sudira, P., & Fara, T. (2024). Research on teacher's digital competency: A bibliometric analysis. In S. B.R. & S. null (Eds.), *AIP Conference Proceedings* (Vol. 3145, Issue 1). American Institute of Physics. https://doi.org/10.1063/5.0214915

Li, H., & Tinmaz, H. (2025). Knowledge mapping of research on teachers' digital competence in China: a bibliometric analysis using CiteSpace. *Journal of Computers in Education*, *12*(1), 315–338. https://doi.org/10.1007/s40692-023-00311-w

Liu, C., & Xu, Y. (2025). A visual analysis of the research literature on teachers' digital literacy (2015–2024). *Frontiers in Education*, *10*. https://doi.org/10.3389/feduc.2025.1597121

Liu, X., Jiang, Y., Dai, Y., Song, N., & Mao, X. (2025). Digital Textbook Integration and Teacher Digital Literacy: Pathways to Enhanced Pedagogical Outcomes in Chinese Secondary Schools. *2025 10th International Conference on Distance Education and Learning, ICDEL 2025*, 494–498. https://doi.org/10.1109/ICDEL65868.2025.11193588

Ma, H., & Ismail, L. (2025). Bibliometric analysis and systematic review of digital competence in education. *Humanities and Social Sciences Communications*, *185*(12), 1–17. https://doi.org/10.1057/s41599-025-04401-1

Manowaluilou, N., Thanarachataphoom, T., Pimthong, P., Ugsornkid, S., & Ketkosan, N. (2024). Digital literacy and fluency in education: Enhancing teacher education preparedness policy. *Journal of Infrastructure, Policy and Development*, *8*(8). https://doi.org/10.24294/jipd.v8i8.4415

Momdjian, L., Manegre, M., & Gutiérrez-Colón, M. (2025). A study of preservice teachers' digital competence development: Exploring the role of direct instruction, integrated practice, and modeling. *Evaluation and Program Planning*, *109*. https://doi.org/10.1016/j.evalprogplan.2025.102538

Nagel, I., & Amdam, S. H. (2025). Teachers' Professional Digital Competence. *Encyclopedia*, *5*(3). https://doi.org/10.3390/encyclopedia5030148

Ngoveni, M. A., Mphuthi, G. T., Maile, L. M., Mulaudzi, R. V, Tefo, R. M., & Pitsoane, E. M. (2025). Willing but Underserved: Interpreting Digital Training Needs of Grade 8–12 Teachers in a Rural Libangeni Circuit. *Education Sciences*, *15*(11). https://doi.org/10.3390/educsci15111557

Nguyen, N., Le, H., Truong, B., Ha, D., Nguyen, N., & Tran, T. (2024). A Bibliometric Analysis and Visualisation of Digital Teaching and Learning Publications From Southeast Asia Countries. *European Journal of Education*, *59*(4). https://doi.org/10.1111/ejed.12781

Ohle-Peters, A., & Shahat, M. A. (2023). Differences in instructional quality during the Covid-19 pandemic between Oman and Germany and the role of teacher competences. *Frontiers in Education*, *8*. https://doi.org/10.3389/feduc.2023.1244548

Orekhovskaya, N. A., Pivovarov, V. A., Borovikova, Y. V, Zhirkova, G. P., & Chauzova, V. A. (2024). Analyzing trends in online learning in higher education in the BRICS countries through bibliometric data. *Frontiers in Education*, *May*. https://doi.org/10.3389/feduc.2024.1409013

Papic, A., Jukic, J., & Skojo, T. (2022). Digital Competences of Music Culture Teachers during the COVID-19 Pandemic. In V. N., K. M., G. V., S. K., C. Z., C.-S. M., B. S., S. V., S. D., J. A., G. S., V. B., M. M., T. E., K. T., P. J., G. T.G., & K. B. (Eds.), *2022 45th Jubilee International Convention on Information, Communication and Electronic Technology, MIPRO 2022 - Proceedings* (pp. 599–603). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.23919/MIPRO55190.2022.9803629

Rahimi, A. R., & Daneshvar Ghorbani, B. (2025). Developing and validating the scale of language teachers' computational thinking competency in Computer Assisted Language Learning (LTCCTCALL): Empowering language teaching by cultivating the heart of the 21st-century digital skill. *Asian-Pacific Journal of Second and Foreign Language Education*, *10*(1). https://doi.org/10.1186/s40862-025-00353-w

Rotary-Saban, M., & Shonfeld, M. (2025). Examining the Predictors of Teachers' Self-Efficacy in Digital Science Teaching: the Roles of TPACK, Openness, and School Support. *Research in Science Education*. https://doi.org/10.1007/s11165-025-10302-9

Sánchez, S. P., Belmonte, J. L., Cruz, M. F., & Núñez, J. A. L. (2020). Correlational analysis of the incident factors in the level of digital competence of teachers. *Revista Electronica Interuniversitaria de Formacion del Profesorado*, *23*(1), 143–159. https://doi.org/10.6018/REIFOP.396741

Santos, M. R., & Gomes, M. M. F. (2024). Lifelong digital learning: "computer literacy," "digital literacy," and "digital competence" as dimensions for digital skills. *Revista de Gestao Social e Ambiental*, *18*(1). https://doi.org/10.24857/rgsa.v18n01-028

Sari, P. N., & Sangka, K. B. (2023). Deep Dive into Teachers' Digital Competence to Support 21st Century Learning: A Systematic Literature Review. In K. M., O. O.T., & C. M.L. (Eds.), *Proceedings of International Conference on Research in Education and Science* (Vol. 9, Issue 1, pp. 313–334). The International Society for Technology Education and Science. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85184325066&partnerID=40&md5=fb293e699f8b9c786c90473e9e5c6df8

Spyropoulou, N., Tsitou, S., Vonitsanos, G., Kalantzi, R., & Kameas, A. (2024). Digital Transformation in Adult Education: Empowering Educators to Use DigComp with a MOOC. *Proceedings - Frontiers in Education Conference, FIE*. https://doi.org/10.1109/FIE61694.2024.10892973

Svoboda, P. (2024). Teachers' Digital Competencies: Diagnosis and Development in the Context of the Teacher21 Model. *TEM Journal*, *13*(3), 2195–2207. https://doi.org/10.18421/TEM133-47

Turpo-Gebera, O. W., Chirinos-Tovar, K. R., Manrique-Tovar, F. L., & Huarca-Flores, P. (2025). Digital competencies in future teachers: Field, capital, and habitus in a Peruvian university. *Formacion Universitaria*, *18*(5), 135–148. https://doi.org/10.4067/S0718-50062025000500135

Zhang, K., Fang, H., Kong, X., & Hong, X. (2025). Research on Component Model of Digital Competence and the Key Pathways to Enhancement for Primary and Secondary School Teachers: Based on the Survey Data of National Teachers' Digital Literacy. *ICAITE 2024 - 2024 International Conference on Artificial Intelligence and Teacher Education*, 84–90. https://doi.org/10.1145/3702386.3702401