



Global Research Trends on 21st Century Teacher Competency Using Bibliometric Analysis

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ABSTRACT

Educators are critical facilitators of learning and development in the education system. This study investigates 21st-century teacher competencies in education between 2015 and 2024, analysing publication trends, citation patterns, and their alignment with the Sustainable Development Goals (SDGs). This study uses bibliometric analysis and systematic literature review methodologies, leveraging data from Dimensions.ai (January 15, 2025) via the PRISMA framework, which yielded 985 data points. Analysis through VOS viewer maps collaboration networks and assesses citation impacts, revealing a consistent rise in publications and citations over the period. Notably, the most cited works appeared in reputable, indexed journals. The bibliometric map identifies eight distinct clusters, with “21st-century skills” as the central theme. Current trends link teacher competencies to key areas such as Digital Competency, TPACK (Technological Pedagogical Content Knowledge), Pre-service Teacher preparation, Communication Skills, and Pedagogical Competence. Findings highlight a strong connection between 21st-century competencies and SDG 4 (Quality Education), underscoring their role in improving global education quality. The study emphasizes the necessity of equipping teachers with these competencies to address modern educational challenges effectively. The novelty of this study lies in its integrative approach to bibliometric and systematic review methods to comprehensively map global research trends and gaps in 21st-century teacher competencies over the past decade.



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INTRODUCTION

The rapid evolution of technology, globalization, and societal transformation in the 21st century has profoundly reshaped the landscape of education. As the primary agents of educational change, teachers are expected not only to transmit academic knowledge but also to foster essential 21st-century competencies in students, including critical thinking, digital literacy, communication, collaboration, and creativity (Almazroa & Alotaibi, 2023; Avdiu et al., 2024; Haug & Mork, 2021; Meneses et al., 2023). These demands underscore the urgency of rethinking and redefining teacher competencies to ensure that educators are well-equipped to meet the challenges of modern classrooms and rapidly changing global contexts.

Building on this need, 21st-century teacher competencies have expanded significantly beyond traditional pedagogical knowledge. Contemporary educators are now required to integrate digital technologies, apply innovative teaching strategies, and design inclusive learning environments that are flexible and responsive to students' diverse needs (Bong & Chen, 2024;

Engeness, 2021; Falloon, 2020; Mexhuani, 2025; Miguel-Revilla et al., 2020). In particular, the application of Information and Communication Technology (ICT) and Technological Pedagogical Content Knowledge (TPACK) has become central to effective teaching, reflecting the increasing emphasis on digital competence in educational practices (Akram et al., 2021; Choi & Young, 2021; Elvianasti et al., 2023; Kadioğlu-Akbulut et al., 2023; Ong & Annamalai, 2024; Schmidt & Glaser, 2021; Widajati & Mahmudah, 2023).

Furthermore, research highlights the growing importance of social-emotional and interpersonal competencies in teaching. Leadership, collaboration, and communication are not only essential for managing classrooms but also for building constructive relationships with students, parents, and professional communities (Adom et al., 2021; Aldrup et al., 2020; Bennett et al., 2024; Hoffmann et al., 2020; Riddel & Zulfikar, 2024; Rivas et al., 2022). These skills are especially vital in the context of the Fourth and Fifth Industrial Revolutions (Industry 4.0 and 5.0), which require educators to cultivate not only intellectual capabilities but also empathy, adaptability, and ethical responsibility (Briones et al., 2022; Castro Mosqueda, 2025; Lozano-Peña et al., 2021; Sari et al., 2021; Shanta & Wells, 2022).

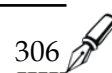
However, despite the increasing theoretical and policy-based emphasis on teacher competencies, empirical research on their practical implementation remains fragmented and unevenly distributed across regions and contexts. Existing studies often focus on narrow case studies or specific competency domains, leaving a broader understanding of the field underdeveloped (Darling-Hammond, 2020; Martin et al., 2022; Midhat Ali et al., 2021; Sonstein et al., 2022). This indicates a research gap between conceptual expectations and the documented realities of teacher preparation and development, thereby highlighting the need for comprehensive mapping of existing research to identify dominant themes, underexplored areas, and influential contributors.

Bibliometric analysis emerges as a critical methodological approach to address this gap. By systematically examining patterns in academic publishing—such as co-authorship networks, keyword co-occurrences, and citation impact—bibliometric methods allow researchers to visualize the evolution of knowledge in a given field (Donthu et al., 2021; Moral-Muñoz et al., 2020). When combined with systematic literature reviews, these tools provide both breadth and depth, enabling scholars to assess the state of research, identify conceptual trends, and guide future inquiry.

This study seeks to map the global research landscape on 21st-century teacher competencies over the past decade (2015–2024) using a combination of bibliometric analysis and systematic literature review. Specifically, it examines trends in publication output, citation dynamics, alignment with Sustainable Development Goals (especially SDG 4 on Quality Education), researcher and institutional productivity, keyword clustering, and patterns of scholarly collaboration. Understanding these patterns is essential to improving policy, research, and practice in teacher education—ultimately supporting the development of a competent teaching force equipped to navigate and lead in the 21st-century educational environment.

RESEARCH METHOD

This study employs a dual-methodological approach that integrates bibliometric analysis and systematic literature review (SLR) to explore global research trends on 21st-century teacher competencies. The integration of these two methods is particularly effective for comprehensively mapping the intellectual and conceptual structure of a research field while simultaneously synthesizing empirical findings. Bibliometric analysis allows for quantitative examination of publication patterns, citation networks, and authorship trends, providing insights into the evolution of the knowledge domain (Baminiwatta & Solangaarachchi, 2021; Hassan & Duarte, 2024; Sabri et al., 2024; Yan & Zhiping, 2023). Meanwhile, the systematic literature review, guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, ensures rigorous selection, transparency, and reproducibility in the identification and analysis of relevant literature (Ardern et al., 2022; Brennan & Munn, 2021; Page et al., 2021; Rethlefsen et al.,



2021). This integrative design has been increasingly applied in educational research to identify gaps, trends, and future research directions (Zhao & Taib, 2022; Pistone et al., 2024; Prahani et al., 2024). Accordingly, the study is guided by the following research question: “What are the dominant research trends, contributors, and thematic focuses in studies related to 21st-century teacher competencies from 2015 to 2024?”.

The data for this study were collected from the Dimensions database (<https://app.dimensions.ai>) on January 15, 2025, by applying the keyword “21st Century Teacher Competency” to the titles and abstracts of publications from 2015 to 2024. The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021; Rethlefsen et al., 2021; Sohrabi et al., 2021) to ensure methodological transparency and replicability. This protocol is consistent with recent research adopting bibliometric and systematic approaches in educational contexts (Chung et al., 2023; Martucci et al., 2023). An initial pool of 1,505 records was retrieved. The eligibility of each document was determined using clearly defined inclusion and exclusion criteria. Inclusion criteria consisted of: (1) peer-reviewed journal articles and conference proceedings, (2) publications released between 2015 and 2024, (3) studies with a thematic focus on 21st-century teacher competencies, and (4) works situated in the domain of education. Documents were excluded if they were (1) book chapters, dissertations, editorials, or grey literature, (2) not directly related to teacher competencies, (3) duplicates, or (4) lacking essential bibliographic metadata. After applying these criteria, 208 documents were excluded, resulting in 1,297 publications subjected to abstract and full-text screening. A total of 985 documents met the final eligibility criteria and were included in the bibliometric and thematic analysis. The document selection process is illustrated in the adapted PRISMA flow diagram (Figure 1).

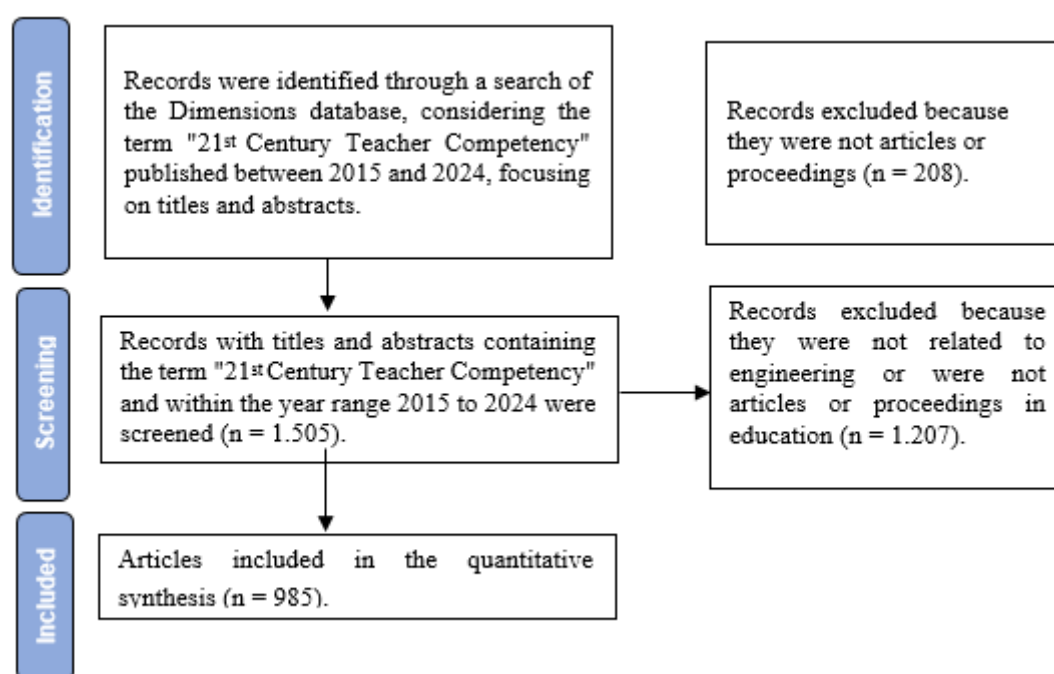


Figure 1. PRISMA flowchart

For the data analysis, this study employed a bibliometric technique supported by VOSviewer version 1.6.19, a widely used software for constructing and visualizing bibliometric networks (Herrera-Franco et al., 2021; Moral-Muñoz et al., 2020; Sun et al., 2024). VOSviewer enables the mapping of co-authorship networks, keyword co-occurrences, citation analysis, and thematic clustering. This process involved analyzing citation frequencies, author collaboration networks, and thematic structures of the field based on co-word analysis. The bibliometric analysis was



complemented by a systematic literature review to contextualize quantitative patterns and highlight major research themes and gaps. The combination of these approaches offers a comprehensive understanding of the research landscape on 21st-century teacher competencies, supporting both structural mapping and interpretative synthesis. Citation frequency was used as a proxy for research influence and scholarly relevance, allowing the identification of high-impact studies and emerging trends in the field.

RESULTS AND DISCUSSION

Result

This section presents a comprehensive bibliometric analysis of 21st-century teacher competencies in education, using data from the Dimensions database (2015–2024). The study examines multiple dimensions: publication volume, citation metrics, disciplinary categories, journal distributions, researcher productivity, network visualizations (co-occurrence and co-authorship patterns), publication clustering, and overlay/density visualizations.

Number of Publications

The systematic search identified 985 relevant scientific articles published between 2015 and 2024. Figure 2 presents the annual distribution of publications examining virtual reality applications in education.

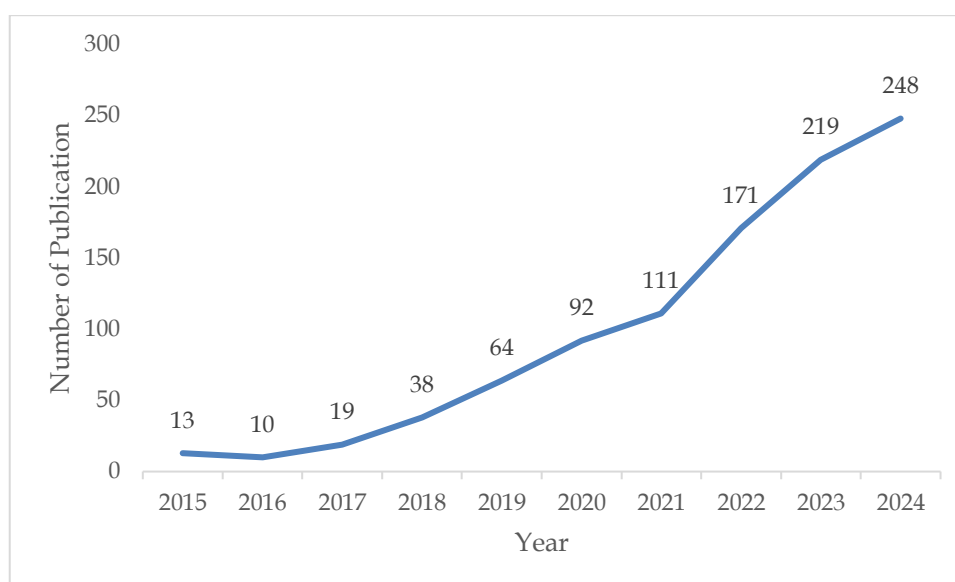


Figure 2. Number of publications on 21st-century teacher competency in 2015–2024

Figure 2 illustrates the annual publication output on 21st-century teacher competencies from 2015 to 2024. The data show a consistent upward trend in scholarly production over the decade. The lowest output occurred in 2016 (10 publications), contrasting sharply with the peak in 2024 (248 publications). The average annual publication rate over the ten-year period was 100.5, reflecting sustained growth in research activity. This trajectory underscores both increasing academic interest and recognition of the field's importance in educational research.

Number of Citations

Publications on 21st-century teacher competencies accumulated 4,786 total citations between 2015 and 2024. Figure 3 details the annual citation patterns.

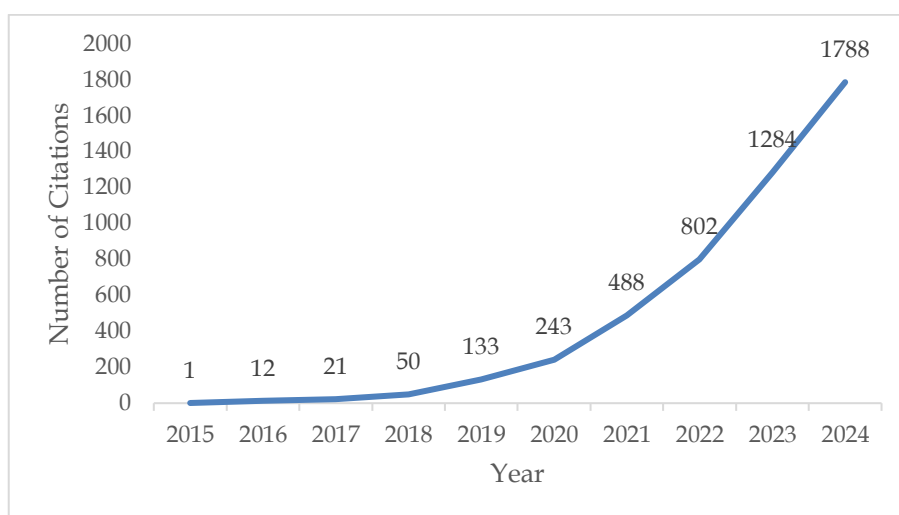


Figure 3. Number of citations on 21st-century teacher competency in 2015–2024

Figure 3 depicts the annual citation trends for publications on 21st-century teacher competencies. The data show a steady rise in citation frequency each year. The lowest citation count (5) occurred in 2015, the study's first year, while 2024 saw the highest (1,788 citations). The average annual citation rate over the decade was 478.6. Among the 985 analyzed publications, the most cited work is "Components of Education 4.0 in 21st Century Skills Frameworks: Systematic Review" (González-pérez et al., 2022) with 339 citations. Published in the Scopus-indexed journal *Sustainability* (Q2, SJR 0.66 in 2023), its high citation count underscores both its academic rigor and the journal's recognized standing in the field.

This analysis aligns with prior bibliometric research (Aroeira & Castanho, 2020; Pahwa et al., 2022; Thelwall et al., 2023), which shows that journal indexing status positively influences citation potential. Consequently, highly cited works like this study's exemplar contribute significantly to shaping scholarly discourse on 21st-century teacher competencies.

SDGs

The research corpus was further analyzed for its contributions to the United Nations SDGs. Figure 4 maps the distribution of publications across the eleven most frequently addressed SDG domains.

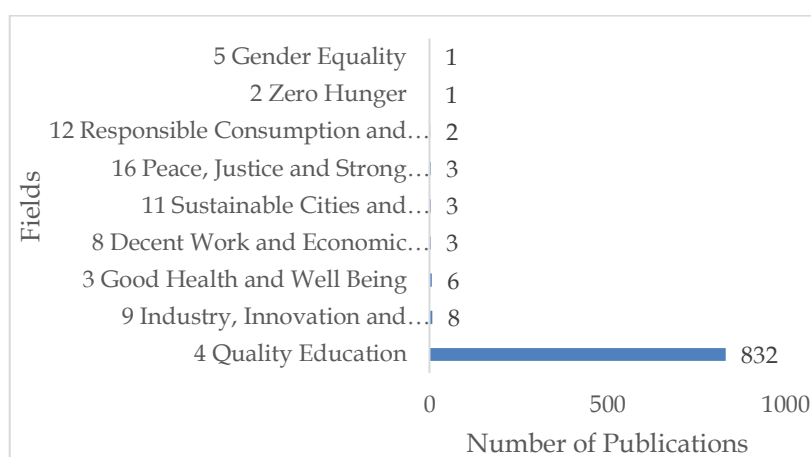


Figure 4. Number of publications on 21st-century teacher competency in education across SDG fields



Figure 4 shows that Sustainable Development Goal 4 (Quality Education) accounts for the majority of publications (n = 832) focused on 21st-century teacher competencies. This dominance underscores the critical role of teacher competency development in advancing quality education within the SDG framework.

Journal

The publication venues for research on 21st-century teacher competencies highlight distinct patterns in scholarly dissemination. Figure 5 illustrates the distribution across the top eleven journals in this field.

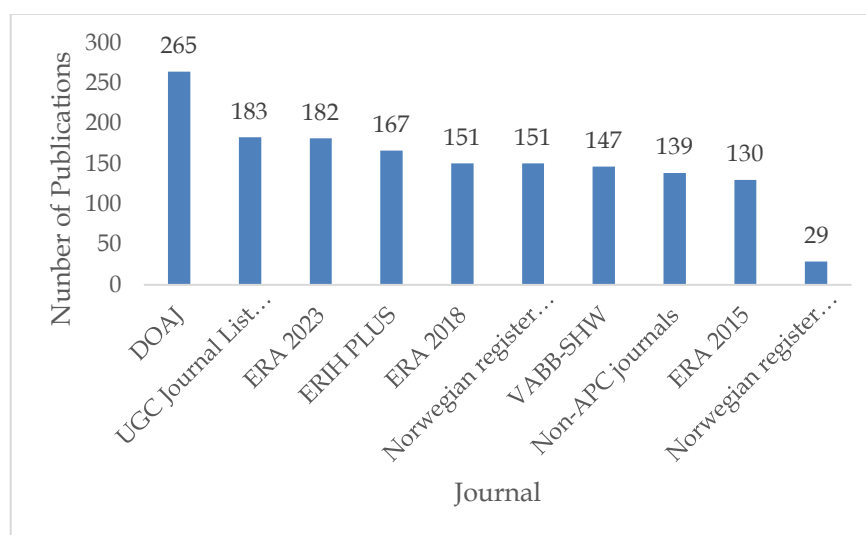


Figure 5. Number of publications on 21st-century teacher competency in education by journal

Figure 5 shows that the Directory of Open Access Journals (DOAJ) hosts the most publications (n = 265) on 21st-century teacher competencies, followed by the UGC Journal List Group II (n = 183). This distribution highlights DOAJ's leading role in disseminating research in this area.

Researcher

Figure 6 identifies the five most productive researchers in this field based on publication output.

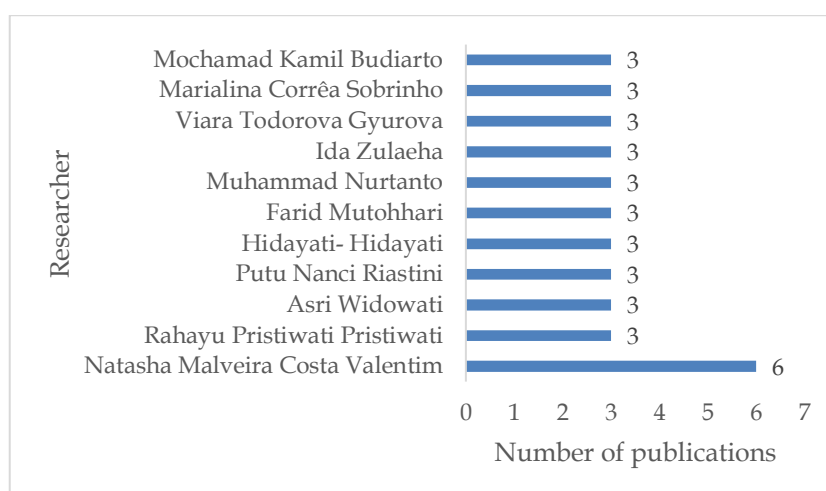


Figure 6. Number of publications on 21st-century teacher competency by researcher (Data source: <https://app.dimensions.ai/>)

Network Visualization for Co-occurrence

As depicted in Figure 7, the co-occurrence network comprises 223 terms organized into 8 clusters, with 10,250 links and a total link strength of 44,340. Terms connected by lines in this visualization (e.g., “Century skill” and “teacher competency”) demonstrate co-occurrence in titles and abstracts, reflecting established conceptual relationships. Conversely, terms lacking direct connections, such as “ICT competency” and “professional teacher”, indicate they have not been co-mentioned in the literature. This network analysis facilitates the identification of emerging research directions and potential gaps, such as the indirect association between “Century skill” and “professional teachers” (mediated via “teacher competency”) and the absence of a direct link between “Century skill” and “ICT competency” (Lam et al., 2022).

Overlay Visualization for Co-occurrence

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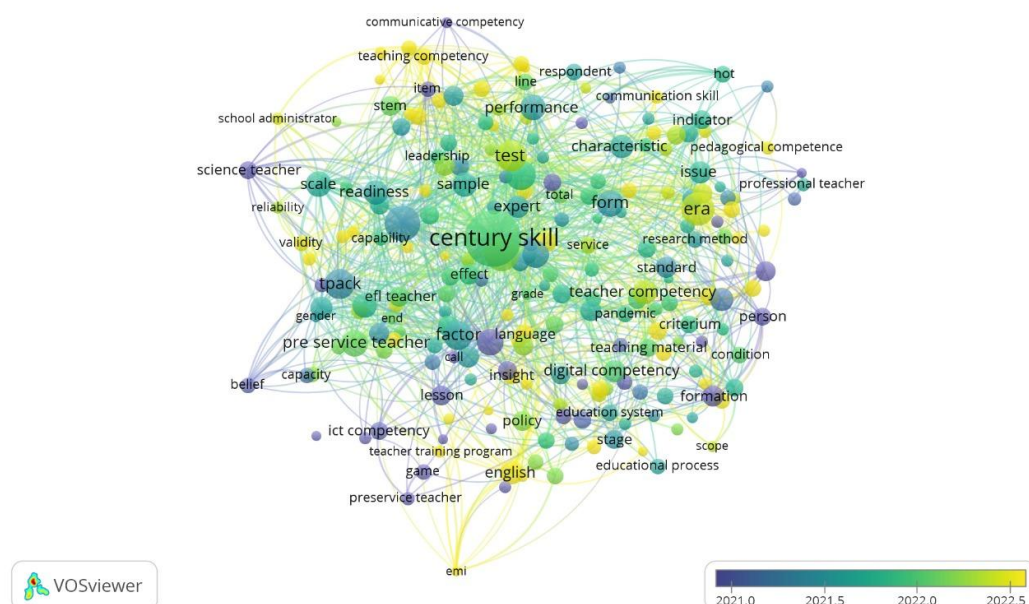


Figure 8. Overlay visualization of 21st-century teacher competency research trends

Figure 8 presents an overlay visualisation of keyword trends in 21st-century teacher competency research, focusing specifically on virtual reality-related terms published between 2015 and 2024. The chromatic coding scheme, following (Lam et al., 2022), identifies keywords of current research interest through their yellow coloration. This temporal analysis reveals that contemporary scholarship predominantly examines connections between "21st Century Teacher Competency" and several key concepts: digital competency, teacher competency, Technological Pedagogical Content Knowledge (TPACK), pre-service teacher development, communication skills, and pedagogical competence.

Density Visualization for Co-occurrence

To complement this analysis, VOSviewer produces density visualization maps to depict term frequency and co-occurrence patterns. Figure 9 specifically illustrates the density visualization for 208 co-occurring terms within this field of study.

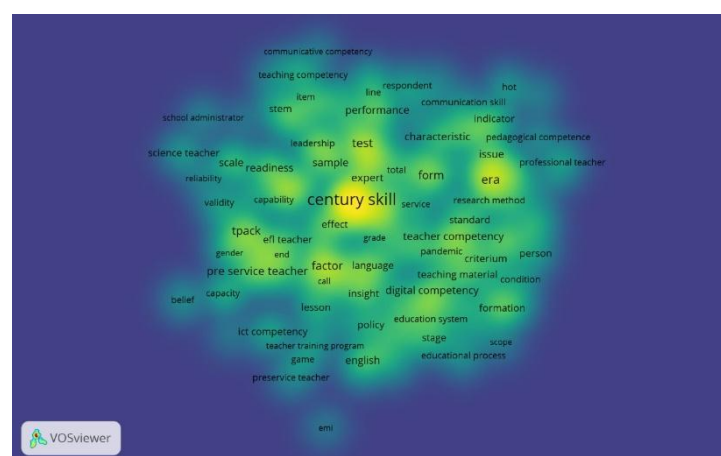


Figure 9. Density visualisation on 21st-century teacher competency (Source: VOS viewer and <https://app.dimensions.ai/>)



Figure 9 illustrates a density visualization mapping research concentrations in 21st-century teacher competency studies. The color gradient ranges from yellow (indicating high-density areas representing well-established topics) to blue (denoting low-density areas signaling underexplored subjects). This visualization identifies research gaps, with low-density zones meriting further scholarly attention. Key terms such as professional teacher development, communicative competency, pedagogical competence, preservice teacher preparation, teaching competency frameworks, and school administrator roles exhibit varying density levels in relation to “21st-century teacher competency.” These patterns underscore both entrenched research areas and emerging opportunities for future inquiry.

Discussion

This study investigates the global research landscape on 21st-century teacher competencies through an integrated bibliometric and systematic literature review approach. The findings highlight significant publication trends, dominant thematic foci, and emerging directions that have shaped scholarly discourse over the past decade. Notably, the annual publication rate shows a steady increase, culminating in a peak of 248 publications in 2024. This upward trajectory reflects intensified academic and policy-level engagement with teacher competency development, corroborating global initiatives that position teacher quality at the core of educational transformation in UNESCO (2024). The average annual output of 100.5 publications indicates sustained interest, especially in alignment with the Sustainable Development Goals (SDGs), particularly SDG 4: Quality Education (Carvalho et al., 2024; Ferrer-Estévez & Chalmeta, 2021; Saini et al., 2023).

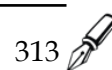
A substantial portion of the retrieved literature ($n = 832$) explicitly relates to the SDG framework, reinforcing the centrality of teacher competence in achieving equitable and inclusive education. These findings are consistent with arguments by Pantić and Florian (2015), who advocate for context-sensitive teacher development frameworks that integrate global standards with localized implementation strategies.

Citation and venue analysis further reveals that publications appearing in high-visibility platforms, such as those indexed by the Directory of Open Access Journals (DOAJ), tend to exhibit greater academic impact—an observation in line with prior bibliometric studies (Pahwa et al., 2022; Thelwall et al., 2023). With 265 of the analysed articles hosted in DOAJ, this platform emerges as a significant contributor to expanding global access to research on teacher competencies, particularly in under-resourced regions.

From an authorship perspective, the prominence of scholars such as Natasya Malveira Costa Valentim signals a growing emergence of expertise from the Global South, thereby challenging the historically Eurocentric locus of educational research (Aguaded et al., 2022; Sato & Cárcamo, 2024). However, the relatively low number of publications per author indicates a fragmented research landscape, underscoring the need for more robust, sustained, and transnational research collaborations (Shih & Forsberg, 2023).

Keyword co-occurrence mapping reveals that recent studies coalesce around themes including digital competence, Technological Pedagogical Content Knowledge (TPACK), communication skills, pre-service teacher education, and pedagogical expertise. These results affirm earlier frameworks introduced by Koehler and Mishra (2009) and further supported by Voogt (2013), which underline the importance of equipping teachers to thrive in increasingly digital and complex educational environments. Recent studies continue to explore these areas, emphasizing the need for integrative learning opportunities to promote digital competencies in pre-service teachers (Záhorec et al., 2021).

Several underexplored but promising thematic intersections also emerged – particularly the links between “21st-century skills” and “ICT competence,” as well as between “professional teachers” and “competency frameworks.” These intersections suggest fertile ground for future inquiry, especially in relation to teacher education programs and school leadership initiatives (Izzati et al., 2023; Tondeur et al., 2023).



Density visualization further indicates uneven research attention across certain clusters, such as the roles of school administrators, preservice teacher preparation, and instructional leadership. These underrepresented areas warrant deeper conceptual exploration. For instance, Bernstein's Code Theory (2000) may provide a valuable lens for examining how curriculum and assessment frameworks shape teacher knowledge structures, while Vygotsky's Zone of Proximal Development (ZPD) (1978) offers insights into the role of scaffolding and mentorship in teacher professional growth.

In addressing the core research question—“What are the dominant research trends, contributors, and thematic focuses in studies related to 21st-century teacher competencies from 2015 to 2024?”—this study concludes that the field is both expanding and diversifying. The thematic evolution reflects increasing attention to digital integration, competency-based learning, and inclusive professional development. While the growing volume and diversity of publications point to a healthy knowledge domain, the field's structural fragmentation and thematic concentration suggest the need for integrative conceptual models and longitudinal investigations to trace the evolution of competencies over time.

These findings provide a critical foundation for understanding the evolving trajectories and persistent challenges within the field of 21st-century teacher competency research. By identifying dominant themes, key contributors, and gaps in scholarly attention, the analysis offers valuable insights into how teacher competencies are being conceptualized and operationalized across different educational contexts. Moreover, the study underscores the importance of collaborative, cross-national efforts and the integration of digital, pedagogical, and intercultural skills in teacher development.

CONCLUSION

This study presents several important implications for educational researchers, policymakers, teacher education institutions, and curriculum developers. The findings highlight the growing academic attention to 21st-century teacher competencies, as evidenced by the increasing volume of publications and citation activity. The identification of key clusters such as Digital Competency, TPACK, and Pedagogical Competence through bibliometric visualization offers clear direction for teacher education programs to align more effectively with technological demands and the skills required in modern education. The strong connection with Sustainable Development Goal (SDG) 4 also reinforces the strategic role of teacher competency development in achieving quality education globally.

However, the study also has some limitations. First, relying solely on the Dimensions database may restrict the comprehensiveness of the literature reviewed, as relevant publications indexed in other databases or published in local journals may have been excluded. Second, the focus on English-language publications introduces a language bias that may overlook valuable contributions from non-English-speaking countries. Third, the bibliometric approach is primarily quantitative and does not offer in-depth qualitative insights into the content, theoretical frameworks, or educational contexts of the analyzed studies. Lastly, the dataset is limited to publications up to 2024, which may not reflect the most recent or rapidly emerging trends.

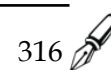
For future research, it is recommended to conduct qualitative meta-syntheses to explore deeper theoretical perspectives, methodologies, and implications of key studies in the field. Expanding the scope to include non-English literature and local databases such as SciELO or national repositories would help represent more diverse global perspectives. Comparative cross-country studies are also needed to examine how 21st-century teacher competencies are implemented in various educational and policy contexts. Longitudinal research should be conducted to assess the long-term impact of teacher competency development on teaching effectiveness and student outcomes. Furthermore, interdisciplinary studies that integrate fields such as artificial intelligence, digital ethics, and socio-emotional learning can enrich the understanding of evolving teacher competencies. Lastly, more attention should be given to the

role of school leadership in supporting the integration of teacher competencies, as this remains a crucial factor in advancing educational quality.

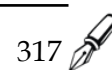
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