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Global Research Trends in the Management of Innovation-Oriented Training in Schools in the Digital Era: A Bibliometric Analysis

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Abstract. This study mapped global publication trends, research landscapes, and thematic evolution in innovation-oriented training management in schools in the digital era. A bibliometric design was used to analyze Scopus-indexed publications. Data was retrieved on January 31, 2026, using a structured search of titles, abstracts, and keywords. A total of 323 documents (2016–2025) were selected through the Preferred Reporting Items for Systematic reviews and Meta-Analyses procedure, including document filtering and metadata verification. Metadata cleaning was conducted using OpenRefine, and the analysis was performed using Biblioshiny (Bibliometrix R) and VOSviewer. The novelty lies in positioning innovation-oriented training management as a unified research domain, rather than fragmented themes such as leadership, professional development, or technology adoption. The findings revealed a significant increase in publications after 2022, with a peak in 2024–2025. Core publication sources consistently address continuing professional development, digital leadership, and technology-integrated training systems. Influential documents emphasized the integration of institutional support, digital competence, and leadership in managing innovation-oriented training. The thematic evolution indicated a shift from early concerns with technology adoption and platform effectiveness to systemic digital transformation, strategic leadership, and advanced digital competencies, including artificial intelligence. The study contributes theoretically by positioning training management as a strategic component of systemic digital school transformation. Pedagogically, the results inform the design of digital classrooms and learning management systems-based training by emphasizing data-driven evaluation, adaptive learning systems, and continuous professional development. These insights support evidence-based policy and practice in digital education.

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1. Introduction

The era of digital education has profoundly changed the way schools organize teaching, learning, and professional practice. The transformation of classrooms through the internet extends beyond the use of digital devices. It also involves changes in pedagogical design, learning environments, and institutional governance (Engelbrecht et al., 2020). The development of artificial intelligence, learning management systems, and data-driven technologies further demands that school leadership strategically steer these changes (Karakose et al., 2021; Zhang et al., 2025). This transformation imposes new demands on school systems to develop innovation-oriented capacities that align pedagogical goals with technological advancements.

In the context of ongoing digital transformation, training and professional development have become primary mechanisms for sustaining innovation in schools. Community-based professional development and blended learning models have strengthened teachers' capacity to integrate technology meaningfully (Phillips et al., 2019; Trust & Horrocks, 2017). In addition, teachers' digital competence readiness is a crucial factor in the successful implementation of online learning and systemic transformation (Perifanou et al., 2021). However, the effectiveness of training is not determined solely by the content or platform used. Institutional support, digital leadership, and structured program management are essential to ensuring that training initiatives align with long-term school strategies (Almusharraf & Khahro, 2020; Wu et al., 2016). Therefore, effective management practices are central to aligning innovation-oriented training with organizational goals and digital transformation agendas.

Studies on innovation-oriented training have expanded across disciplines and educational contexts. Researchers have widely published studies on technology integration, digital leadership, professional competencies, and organizational transformation across various domains (Garone et al., 2019; Silva et al., 2019). Several studies have examined the effectiveness of digital training implementation and participant experiences, including research on online learning satisfaction (Almusharraf & Khahro, 2020) and teachers' digital skills readiness (Perifanou et al., 2021). Other studies have evaluated online-based professional development models (Phillips et al., 2019). This growth has created a vast and increasingly complex body of literature. Although these studies provide significant empirical contributions, the rapid expansion of publications may obscure research gaps and emerging directions. Consequently, there is a need for studies that systematically map research development patterns and thematic evolution in this field.

Researchers have conducted several reviews of digital transformation and professional development management in the education sector. For example, Khurshid et al. (2021) reviewed the effectiveness and sustainability of quality

improvement programs for health workers and identified their supporting and inhibiting factors. Yuliandari et al. (2023) reviewed digital transformation in secondary schools and identified leadership and professional development as key enabling factors. Zeng et al. (2025) reviewed studies that emphasized the role of school principals' digital leadership in enhancing teachers' competence in integrating artificial intelligence. Hariyanti et al. (2025) conducted a bibliometric review to map global trends and identify emerging themes in school leadership development. In addition, Alkan et al. (2025) explored principals' perceptions of artificial intelligence and big data, highlighting gaps in technology readiness.

However, these studies do not specifically map the development of innovation-oriented training management in schools as an integrated field. They tend to examine leadership, digital transformation, or professional development separately. This creates a gap in understanding how innovation-oriented training is managed systematically in the digital era. Moreover, limited evidence is available to inform digital education policy and school-level practice regarding training design, implementation, and evaluation. A comprehensive bibliometric analysis is therefore needed to identify research patterns, key themes, and emerging directions. Such analysis can provide evidence-based insights to support policy formulation and improve training practices in digital education contexts.

To address this gap, this study presents a bibliometric analysis of global research on innovation-oriented training management in schools during the digital education era. It focused on publications from the last decade (2016–2025) to ensure relevance to current educational developments. This study aimed to identify publication trends, key themes, and emerging research directions in training management and innovation in schools. Its novelty lies in the integrative examination of training, innovation, and management within a single bibliometric framework. By providing a structured overview of the intellectual landscape, this study contributes to theoretical development and informs future research agendas. It also offers policymakers and school leaders evidence-based insights into designing sustainable, innovative-oriented training strategies. Three research questions guided the study:

1. What are the annual publication trends in innovation-oriented training management research in schools during the digital education era over the past decade?
2. What are the main journal sources, influential documents, and patterns of international collaboration in innovation-oriented training management research in schools during the digital education era over the past decade?
3. What are the dominant and emerging research themes in innovation-oriented training management research in schools during the digital education era over the past decade?

2. Methodology

2.1 Research Design

This study employed a bibliometric research design to systematically map and analyze global scientific publications on innovation-oriented training management in schools during the digital education era. Bibliometric analysis was selected because it enabled a quantitative and structured examination of a large body of scientific literature. This approach facilitated the identification of publication trends, relevant sources, patterns of international collaboration, contributing institutions, influential documents, and the evolution of research themes over time. By applying bibliometric techniques, this study provides a comprehensive overview of the intellectual structure and research dynamics in this interdisciplinary field. However, bibliometric analysis has inherent limitations, as it relies on metadata and quantitative indicators that may not fully capture the depth, context, and quality of individual studies.

2.2 Search Strategy and Data Collection

This study collected data from the Scopus database on January 31, 2026. Scopus was selected because it provides extensive coverage of peer-reviewed international journals, conference proceedings, and multidisciplinary research outputs. It also provides standardized, comprehensive metadata, including author information, institutional affiliations, keywords, abstracts, and citation data. These features are essential for rigorous bibliometric analysis (Ningsih et al., 2026). Nevertheless, the exclusive use of Scopus may have introduced database bias. It predominantly indexes English-language publications and high-visibility journals, which may underrepresent regional or non-indexed studies.

To capture literature reflecting a management perspective on innovation-oriented training in schools in the digital education era, a comprehensive search strategy was developed. The search incorporated keywords aligned with the research focus and included relevant synonyms. The query was carefully constructed and validated by three co-authors to ensure its relevance and coverage. It was then applied to titles, abstracts, and keywords: (management OR leadership) AND ("innovation training" OR "professional development") AND (school* OR "K-12 education" OR education) AND ("digital transformation" OR "educational technology" OR "digital education" OR "ICT in education" OR "online learning" OR "blended learning"). However, keyword bias may still have occurred, as studies using different terms or emerging concepts might not be captured in the dataset.

The document selection process followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines (Moher, 2016), as illustrated in Figure 1. The initial search yielded 543 documents. To ensure temporal relevance and consistency, the dataset was limited to publications from 2016 to 2025. This restriction reduced the number of documents to 377. The screening process then considered document types. The analysis included only articles, conference papers, reviews, and conference reviews because these document types provide sufficient empirical or conceptual contributions for

bibliometric purposes. Books, book chapters, notes, editorials, and data papers were excluded. After applying these criteria, 327 documents remained.

All selected documents were exported in Comma-Separated Values (CSV) format to verify the metadata. A manual inspection of the CSV files assessed data completeness. During this process, four documents lacked essential information, including author names and institutional affiliations. These documents were excluded. As a result, the final dataset for bibliometric analysis consisted of 323 documents.

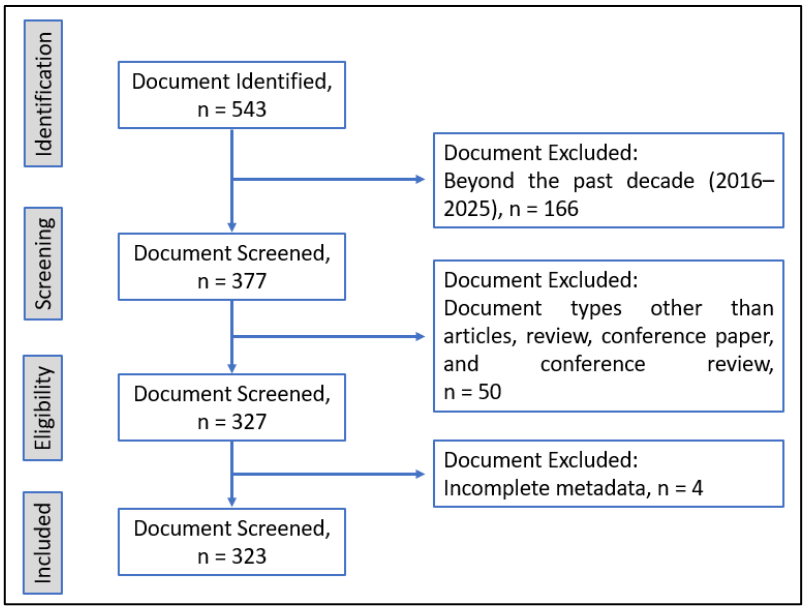

Figure 1: PRISMA flowchart of metadata collection

2.3 Data Analysis

Prior to the analysis, metadata were cleaned in OpenRefine to standardize variations in author names, institutional affiliations, and keyword spellings. This step improved data consistency and prevented fragmentation in subsequent analyses. The study then employed two complementary tools: Biblioshiny (the web-based interface of the Bibliometrix R package) and VOSviewer. Biblioshiny analyzed annual publication trends over 10 years. It also identified relevant journal sources and the most productive countries to examine patterns of research collaboration (Ningsih et al., 2026; Sitepu et al., 2026). In addition, the analysis identified potential publication outlets and influential documents based on citation metrics. These indicators provided insights into research productivity, scholarly influence, and the field's structural development.

VOSviewer visualized and explored the intellectual structure of the field based on authors' keywords. The analysis mapped major research domains, examined keyword co-occurrence networks, identified emerging research themes, and detected potential future research directions (Salido et al., 2025). The results from Biblioshiny and VOSviewer were systematically compared and cross-validated to enhance analytical accuracy, minimize methodological bias, and strengthen the credibility of the findings.

Each analytical result was interpreted within its contextual framework and supported by relevant literature and metadata from the collected documents. Three senior authors with expertise in the field reviewed and validated interpretations to reduce potential bias. Any differences in interpretation were resolved through discussion and consensus. Despite these efforts, the interpretation of bibliometric visualizations remained subject to researcher judgment, which may have introduced interpretive bias.

3. Results and Findings

3.1 Annual Scientific Production of Innovation-Oriented Training Management Research in Schools (2016–2025)

Figure 2 presents the annual distribution of publications on innovation-oriented training management in schools during the digital education era from 2016 to 2025. Overall, the publication trend fluctuated in the early years and then increased gradually until 2022. Between 2016 and 2018, the number of publications remained relatively low, showing minor year-to-year variations. From 2019 to 2022, annual publications increased more steadily, although the growth rate was moderate.

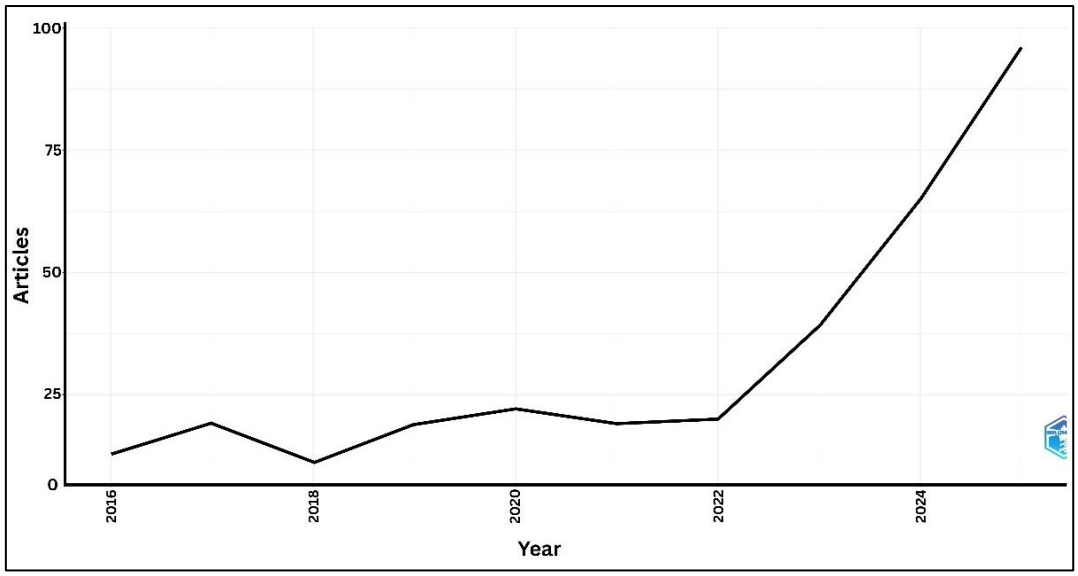

Figure 2: Annual publication trends in innovation-oriented training management research in schools (2016–2025)

Furthermore, since 2022, the number of publications has increased more sharply than in previous years. This upward trend continued through 2024 and reached its peak in 2025. The pattern indicates a transition from moderate growth to a more substantial expansion phase during the last four years of the observation period.

3.2 Research Landscape of Innovation-Oriented Training Management in Schools (2016–2025)

The analysis of 323 documents shows that studies on innovation-oriented training management in schools were published across journals focusing on education and educational technology. Figure 3 presents the 10 most productive journal sources.

The distribution indicates a concentration of articles in several leading journals in education and professional development.

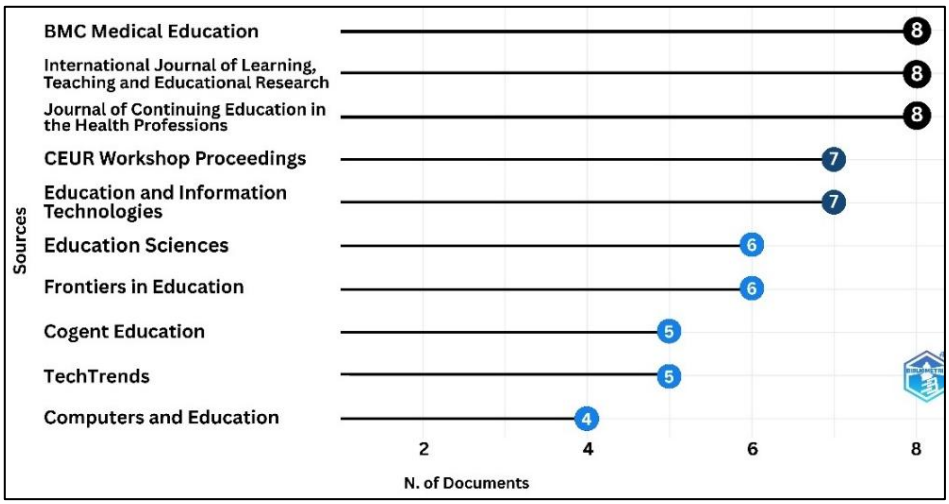

Figure 3: Top 10 journal sources in innovation-oriented training management research in schools (2016–2025)

As shown in Figure 3, *BMC Medical Education, International Journal of Learning, Teaching and Educational Research,* and the *Journal of Continuing Education in the Health Professions* each published eight documents, making them the most productive sources during 2016–2025. *CEUR Workshop Proceedings* and *Education and Information Technologies* followed with seven documents each. *Education Sciences* and *Frontiers in Education* each published six documents. Cogent Education and *TechTrends* contributed five documents each, while *Computers and Education* published four documents.

These findings indicate that the topic spans journals in general education, educational technology, and professional development. The concentration of publications in these outlets suggests that innovation-oriented training management intersects with discussions on educational leadership, digital transformation, and technology-enhanced learning. The theme appears embedded within broader debates on how educational institutions adapt to digital change and strengthen human resource capacity. To further examine scholarly influence, the analysis identified the 10 most cited documents based on global citations, as presented in Table 1.

Table 1 lists the 10 documents with the highest global citation counts that shaped research development in this field. Almusharraf and Khahro (2020), published in the *International Journal of Emerging Technologies in Learning*, ranked first with 218 citations. Tsay et al. (2018) published in *Computers & Education*, followed with 216 citations. Karakose et al. (2021), published in *Sustainability*, ranked third with 203 citations. These three works form a core cluster of highly cited literature, with only small differences in citation counts.

Based on total citations per year, Karakose et al. (2021) achieved the highest score (33.83), indicating a rapid citation growth within a relatively short period. The same article also recorded the highest normalized citation score (8.04), followed by Tsay et al. (2018) with 7.59 and Almusharraf and Khahro (2020) with 6.92. These results suggest that article influence depends not only on cumulative citations but also on citation intensity and continued relevance to recent research developments.

Table 1: Top 10 cited documents in innovation-oriented training management research in schools (2016–2025)

Paper and Journal Short Title	DOI	TC	TC/Y	NTC
Almusharraf & Khahro (2020), *Int J Emerg Technol Learn*	10.3991/ijet.v15i21.15647	218	31,14	6,92
Tsay et al. (2018), *Comput Educ*	10.1016/j.compedu.2018.01.009	216	24,00	7,59
Karakose et al. (2021), *Sustainability*	10.3390/su132313448	203	33,83	8,04
Engelbrecht et al. (2020), *ZDM Math Edu*	10.1007/s11858-020-01176-4	143	20,43	4,54
Lawn et al. (2017), *BMC Med Educ*	10.1186/s12909-017-1022-0	102	10,20	4,35
Garone et al. (2019), *Br J Educ Technol*	10.1111/bjet.12867	98	12,25	4,49
Phillips et al. (2019), *Med Educ*	10.1111/medu.13895	94	11,75	4,30
Silva et al. (2019), *Comunicar*	10.3916/C61-2019-03	74	9,25	3,39
Biasutti et al. (2022), *Musicae Scientiae*	10.1177/1029864921996033	73	14,60	5,51
Perifanou et al. (2021), *Int J Emerg Technol Learn*	10.3991/ijet.v16i08.21011	73	12,17	2,89

Note. TC: Total Citations; TC/Y: Total Citations per Year; NTC: Normalized Total Citations

Other influential documents include Engelbrecht et al. (2020) in *ZDM Mathematics Education*, Lawn et al. (2017) in *BMC Medical Education*, Garone et al. (2019) in the *British Journal of Educational Technology*, and Phillips et al. (2019) in *Medical Education*. These works received between 94 and 143 citations. Silva et al. (2019) in *Comunicar*, Biasutti et al. (2022) in *Musicae Scientiae*, and Perifanou et al. (2021) in the *International Journal of Emerging Technologies in Learning,* received between 73 and 74 citations. Their normalized citation scores ranged from 2.89 to 5.51, indicating a stable level of influence throughout the observation period. Overall, the most influential literature over the past decade has concentrated on digital technology integration, professional development, and leadership in educational transformation contexts. Furthermore, the study examined the distribution of corresponding authors' countries and patterns of international collaboration, as shown in Figure 4.

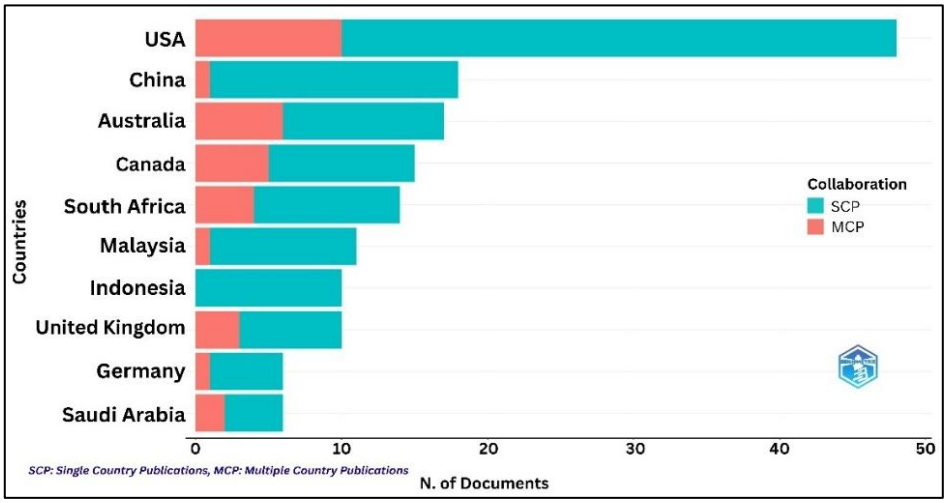

Figure 4: Top 10 corresponding authors' countries in innovation-oriented training management research in schools (2016–2025)

Figure 4 shows that the United States ranked first in terms of corresponding author publications. Its total output substantially exceeded that of other countries. Most publications were single-country publications (SCPs), although multiple-country publications (MCPs) also contributed a notable share. This pattern indicates strong domestic research capacity combined with active international collaboration. China and Australia followed in the second and third positions. China's output was dominated by SCPs, with a smaller proportion of MCPs. In contrast, Australia demonstrated a more balanced distribution between domestic and collaborative publications.

Canada and South Africa formed the middle group. Both countries showed consistent publication output, with SCPs dominating but MCPs remaining visible. Malaysia and Indonesia also appeared in the top 10, although with different profiles. Malaysia combined SCPs and MCPs, with domestic publications prevailing. Indonesia's output was largely dominated by SCPs, indicating limited international collaboration in this field.

The United Kingdom, Ireland, and Saudi Arabia completed the top 10. The United Kingdom displayed a relatively balanced composition of SCPs and MCPs, reflecting active participation in cross-national research networks. Ireland and Saudi Arabia contributed fewer publications, with SCPs dominating and MCPs representing a smaller share. Overall, research production on innovation-oriented training management in schools remains concentrated in a limited number of countries, with varying degrees of international collaboration.

3.3 Key and Emerging Themes in Innovation-Oriented Training Management Research in Schools (2016–2025)

A keyword co-occurrence analysis was conducted using VOSviewer with a minimum threshold of five occurrences. The analysis applied a thesaurus file to standardize keyword variations and exclude general methodological terms, such as articles, thematic analysis, systematic review, qualitative research, and priority journal. Figure 5 presents the network visualization results. The analysis

identified four interconnected clusters. The network structure indicates that professional development is the most dominant keyword and serves as the central node connecting various concepts in this research domain.

The first cluster (red) consists of 46 items and centers on professional development within digital transformation contexts. Strongly connected keywords include professional development, teacher professional development, teaching, curriculum development, curriculum development, pedagogy, student, higher education, and engineering education. The technological dimension appears through terms such as digital transformation, digital education, digital technologies, educational technologies, technology integration, education computing, e-learning, blended learning, learning systems, learning management system, and computer-assisted instruction. Contemporary issues also emerge through COVID-19 and artificial intelligence. Organizational aspects appear through personnel management. The density of connections within this cluster reflects strong integration between pedagogical innovation and digital transformation.

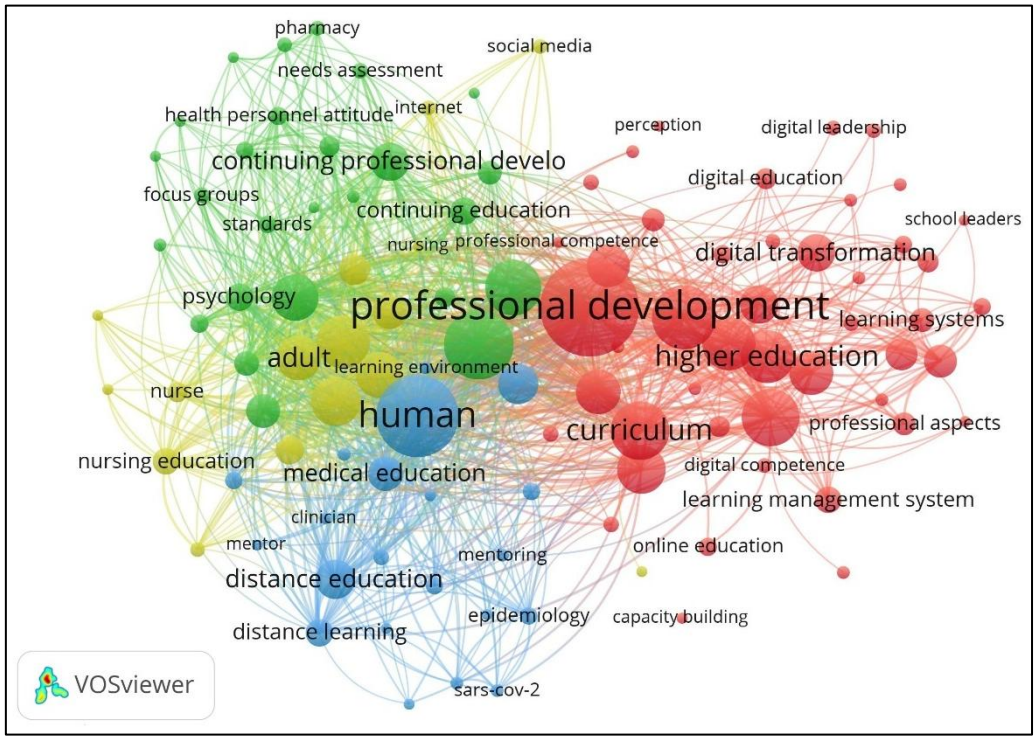

Figure 5: Keyword co-occurrence network in innovation-oriented training management research (2016–2025)

The second cluster (green) consists of 26 items and emphasizes sustainable development and organizational management. Key terms include continuing professional development, continuing education, organization and management, program evaluation, needs assessment, information management, and procedures. Professional competence and individual capacity appear through skills, clinical competence, health care personnel, health personnel attitude, and pharmacy. The cluster also connects to online learning and incorporates a social-

psychological perspective through psychology. This pattern indicates that research in this domain focuses on program evaluation and capacity building within professional development systems.

The third cluster (blue) includes 21 items and focuses on leadership and practice-based professional education. Prominent keywords include leadership, medical education, medical continuing education, medical student, clinical practice, and learning environment. Distance education contexts appear through distance education and distance learning. Organizational quality appears through total quality management. Global health issues emerge through epidemiology and SARS-CoV-2, while mentoring reflects support for individual professional growth. The fourth cluster (yellow) consists of 16 items that represent participant characteristics and the social context of learning. These include adult, female, male, middle-aged, learning, human experiment, staff development, student engagement, nurse, nursing, nursing education, nursing student, social media, and internet. Overall, Figure 5 demonstrates that research themes are structured across four interconnected domains, with professional development and digital transformation occupying central positions in the network.

To examine thematic evolution over time, the analysis applied overlay visualization, as presented in Figure 6. This visualization illustrates the temporal dynamics of keyword occurrence between 2016 and 2025. During the earlier phase (2019–2020), dominant keywords included learning, human experiment, computer-assisted instruction, information management, clinical competence, health personnel attitude, program development, nursing education, skills, online system, needs assessment, pharmacy education, and curriculum development. This pattern indicates that early research emphasized curriculum strengthening, competency development, and initial technology integration within specific professional contexts.

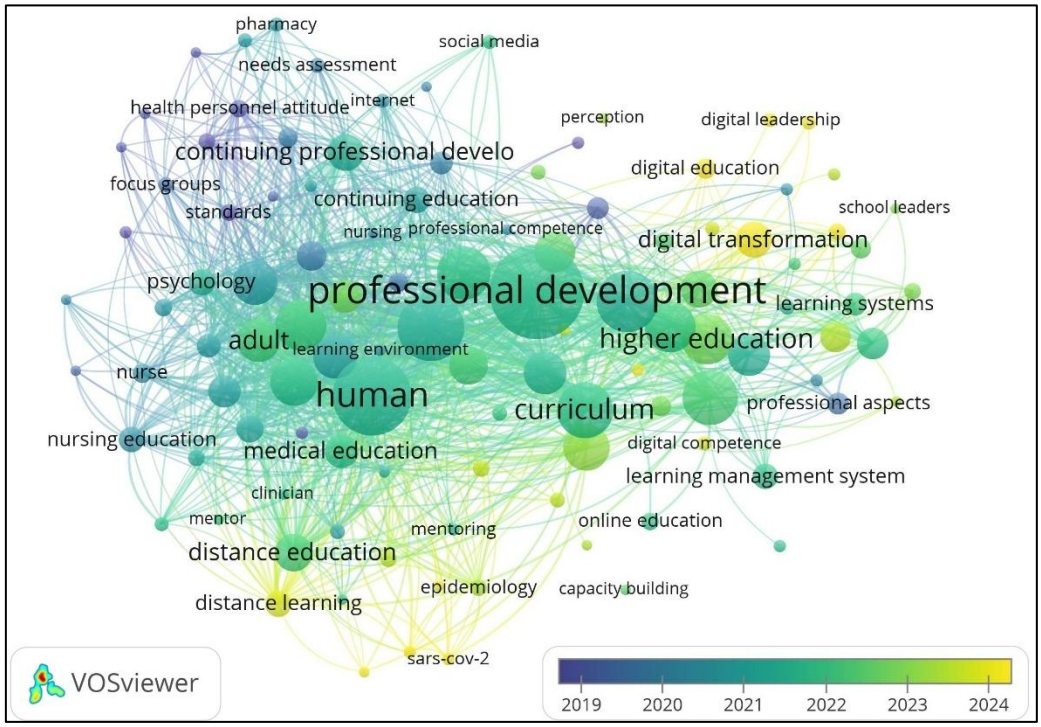

Figure 6: Overlay visualization of keyword evolution in innovation-oriented training management research (2016–2025)

During the mid-period (2021–2022), the focus expanded to broader themes such as professional development, continuing professional development, teaching, education, online learning, medical education, learning systems, learning management systems, and program evaluation. Supporting terms included ICT, online education, mentoring, clinical practice, quality improvement, total quality management, motivation, social media, professional competence, pedagogy, and learning environment. This phase reflects consolidation around learning systems, evaluation frameworks, and quality management within digital education contexts.

In the most recent period (2023–2025), emphasis shifted toward digital transformation, teacher professional development, higher education, blended learning, distance learning, adult, middle-aged, and COVID-19. These keywords appear with medium-sized nodes, indicating increasing research attention. Smaller nodes represent emerging but less extensively studied topics, including artificial intelligence, digitalization, digital competence, digital technologies, digital leadership, digital education, educational leadership, sustainable development, school leaders, training, and digital devices. These emerging themes signal a transition toward strategic agendas that prioritize digital competence and technology-based leadership. Overall, the findings reveal a gradual shift from a focus on foundational competencies and learning management to a broader digital transformation agenda in professional development research.

4. Discussion

4.1 Annual Scientific Production of Innovation-Oriented Training Management Research in Schools (2016–2025)

The increase in publications after 2022 did not emerge abruptly. It reflected the cumulative development of the theme since the early period of 2016–2018. During the initial phase, studies primarily focused on integrating learning technologies and strengthening professional curriculum design. This focus was particularly evident in research on blended learning and technology-based instruction (Teräs & Kartoğlu, 2018; Tsay et al., 2018). Studies by Grehan et al. (2018) and Salisbury (2018) emphasized institutional readiness and educators' attitudes toward technology adoption.

Between 2019 and 2021, research shifted toward a more systemic perspective. Scholars increasingly emphasized sustainable professional development and digital competencies (Engelbrecht et al., 2020; Garone et al., 2019). In this phase, researchers no longer framed technology integration as a supplementary instructional tool. Instead, they positioned it as part of a broader institutional strategy. Almusharraf and Khahro (2020) and Karakose et al. (2021) linked digital transformation to leadership practices and organizational sustainability.

The peak in publication output during 2024–2025 reflected the consolidation of digital transformation as a strategic agenda in training management. Recent studies, such as Altassan (2025), directly associated leadership effectiveness with technological use and organizational transformation. Musie et al. (2025) and Ladur et al. (2025) underscored the importance of continuous professional development and blended learning in strengthening educators' digital capacity. Simelane-Mnisi and Mthimunye (2025) identified lecturers' digital competence as a key determinant of successful educational innovation. Overall, the sharp increase in publications toward the end of the observation period indicated a shift from exploratory studies on technology integration to a stronger emphasis on digital leadership, competency development, and systemic educational transformation.

4.2 Research Landscape of Innovation-Oriented Training Management in Schools (2016–2025)

Publications in *BMC Medical Education* primarily addressed digital-based continuing professional development management and blended learning strategies within health education contexts. Studies on blended learning for healthcare capacity strengthening (Ladur et al., 2025), virtual CPD evaluation using learning management systems (Kerdari et al., 2025), and online community-based continuing medical education (Singh et al., 2024) demonstrated structured and technology-driven training management models. Similarly, the *Journal of Continuing Education in the Health Professions* emphasized managerial and evaluative dimensions of continuing education. Research on program effectiveness and sustainability (Khurshid et al., 2021), online quality improvement models (Dzara et al., 2021), and cross-border communities of practice for faculty development (Filipe et al., 2025) reflected a systematic approach to digitally supported professional training management.

In the field of school leadership and digital management, the *International Journal of Learning, Teaching and Educational Research* featured studies on technological leadership and teacher capacity building (Yang et al., 2025). It also included research on digital teaching innovation as systemic transformation (Wei et al., 2025) and competency development for school administrators (Sudsomboon, 2025). *Education Sciences* strengthened this perspective through studies on artificial intelligence literacy in teacher education (Kelley & Wenzel, 2025) and principals' digital leadership competencies in the context of the Fourth Industrial Revolution (Okunlola & Naicker, 2025). Meanwhile, *Education and Information Technologies* focused on teacher digital competency models (Jiang & Yu, 2024), technology leadership in enhancing student learning experiences (Uzorka & Kalabuki, 2024), and readiness for blended learning implementation (Sanders & Mukhari, 2024). Collectively, these journals positioned training management within a digital transformation framework that emphasized institutional capacity building.

Within the domain of learning technology and school digital transformation, *Computers and Education* highlighted psychological and leadership factors that drove digital transformation (Chen & Kouhsari, 2025). It also included foundational studies on technology-based instructional design (Tsay et al., 2018). *TechTrends* complemented this focus by addressing systemic artificial intelligence integration and the design of continuous learning environments (Henriksen et al., 2025), as well as innovative learning system development (Ramirez et al., 2023). *Frontiers in Education* presented studies on principals' e-leadership (Indra et al., 2022), the influence of digital leadership on teacher competence (Zeng et al., 2025), and hybrid learning evaluation (Yalan & Marcial, 2025). *Cogent Education* and *CEUR Workshop Proceedings* documented practical cases of digital transformation, teacher competency development, distance learning implementation, learning management system use, and crisis response (González et al., 2025; Vakaliuk et al., 2025).

Overall, these 10 sources demonstrated thematic consistency across three domains: digital-based CPD management, leadership and capacity building in school transformation, and the design and evaluation of innovative technology-based training systems. This pattern aligned with the study's focus on global trends in innovation-oriented training management in schools during the digital education era. These journals represented key publication outlets for future research in this field.

Analysis of the 10 most influential documents further clarified the field's intellectual direction. Almusharraf and Khahro (2020) emphasized institutional support and system readiness as determinants of online learning satisfaction. Karakose et al. (2021) and Perifanou et al. (2021) reinforced the importance of digital leadership and teacher competency readiness in school transformation. These works served as central references because they integrated training innovation with governance structures and long-term professional development strategies.

At the pedagogical level, several studies showed that innovation extended beyond technology adoption (Engelbrecht et al., 2020; Garone et al., 2019; Tsay et al., 2018). They emphasized learning design, participant needs analysis, and transformation of learning environments. Their findings supported evidence-based approaches to digital training that adapted to user characteristics. Consequently, concepts such as learning management systems, gamification, and technology integration became core references in innovation-oriented training development.

Phillips et al. (2019) and Lawn et al. (2017) provided empirical evidence on the effectiveness of online and blended professional development models. They highlighted measurable impacts on professional practice. Silva et al. (2019) and Biasutti et al. (2022) addressed challenges related to digital competence and distance learning management, particularly during crises. Together, these 10 documents formed a conceptual framework that explained the shift toward digital leadership, strengthening competency, and sustainable training design in global educational transformation.

Country-level analysis further reinforced this pattern. Publications from the United States emphasized teacher professional development, technological leadership, and digitally driven training design. Studies on school technology leadership, blended and online professional development, and teacher capacity building in technology integration illustrated the country's dominant research orientation (Anderson & Putman, 2023; Trust & Horrocks, 2017; Wu et al., 2016). These findings positioned training management as a strategic mechanism for digital school transformation. Collaborative work between researchers from the United States and the United Kingdom, particularly in blended learning and educational technology development (Tsay et al., 2018), strengthened the role of these countries as central nodes in the global research network.

China demonstrated a strong policy-oriented approach to digital leadership and school system transformation. Research on ICT development in K–12 schools (Du et al., 2016), teacher professional competence (Huang et al., 2017), and the relationship between technology leadership and digital integration (Zhang et al., 2025) reflected a systemic reform agenda. Australia contributed significantly to continuing professional development and blended learning strategies for teacher capacity building (Scott et al., 2017). Its collaborations with the United Kingdom and Canada in online training development and CPD evaluation illustrated a balanced pattern between domestic productivity and international cooperation.

Canada and the United Kingdom emphasized structured and evidence-based professional training models. Research on online CPD and training effectiveness evaluation (Farrell et al., 2019; Phillips et al., 2019) highlighted systematic design principles. Studies from the United Kingdom on blended learning and institutional capacity building (Hill & Smith, 2023; Konstantinou, 2022) demonstrated efforts to integrate digital innovation into school governance. In Southeast Asia, Malaysia and Indonesia focused on principals' digital leadership, teacher competence, and curriculum transformation (Hariyanti et al., 2025;

Setiawan et al., 2024; Zeng et al., 2025). Although international collaboration remained more limited than in Western contexts, domestic research capacity continued to strengthen. Overall, collaboration patterns and thematic orientations confirmed that global research increasingly integrated digital leadership, sustainable professional development, and technology-based school system transformation.

4.3 Key and Emerging Themes in Innovation-Oriented Training Management Research in Schools (2016–2025)

The evolution of research themes indicated that, in the early phase, training management primarily focused on technology integration as an instrument to support learning and enhance professional capacity. Studies on school technology leadership and educational technology standards highlighted the importance of structural readiness in managing digital innovation (Wu et al., 2016; Yu & Prince, 2016). At the same time, research on online learning and training management systems emphasized platform effectiveness and user acceptance (Kite et al., 2020; Salisbury, 2018). These studies also reflected the early role of digital platforms, including learning management systems (LMS), as tools for supporting instructional delivery rather than strategic training systems. During this stage, scholars largely framed innovation as a technical adaptation to information and communication technology developments. It had not yet been fully integrated into long-term institutional strategies.

In the subsequent period, research increasingly emphasized community-based training design and sustainable professional development. Trust and Horrocks (2017) demonstrated how blended learning-based communities of practice fostered collaborative teacher growth. Phillips et al. (2019) confirmed the effectiveness of structured online learning models in improving professional competence through spaced education approaches. In higher education and health contexts, Lawn et al. (2017) stressed the importance of interactive and reflective e-learning design to ensure meaningful engagement rather than passive information delivery. This phase also marked the growing importance of teacher training as a continuous and collaborative process rather than a one-time intervention. These findings reflected a transition from technology adoption toward systematic, evaluation-based, and quality-oriented training management.

The pandemic period accelerated this transformation. Almusharraf and Khahro (2020) showed that student satisfaction with online learning was strongly influenced by institutional readiness, technical support, and lecturer training. Engelbrecht et al. (2020) emphasized that internet-based classroom transformation required changes in pedagogical frameworks and learning environment design, not merely the use of digital tools. Karakose et al. (2021) highlighted the central role of school principals in leading digital transformation and supporting technology-based professional development. During this stage, LMS and digital classroom environments became central components in training implementation and instructional management. Scholars increasingly positioned training management as part of an integrated organizational transformation strategy.

In the most recent phase, research has focused on advanced digital competencies and innovation-driven leadership. Perifanou et al. (2021) identified persistent challenges in long-term planning and digital institutional management despite improvements in teachers' digital skills. Biasutti et al. (2022) reported that remote teaching required curriculum reorganization, adaptive time management, and revised evaluation strategies. Zhang et al. (2025) and Xin et al. (2025) demonstrated the relationship between digital leadership, teacher competence, and learning performance within increasingly digitized educational systems. These studies indicate that digital leadership plays a strategic role in aligning training, technology use, and school vision. These developments indicated that innovation had progressed beyond technological integration. It evolved into the strategic management of digital skills-based training, transformative leadership, and the cultivation of digital school culture.

Overall, the evolution of the research theme reflected a shift from strengthening individual competencies and operational technology integration to consolidating structured, quality-oriented digital learning systems. In the current phase, attention shifted toward comprehensive digital transformation management. This shift includes aspects of school leadership, digital organizational culture, and continuous professional development. The literature demonstrated that innovation-oriented training management was no longer a purely technical activity. It increasingly informs the design of teacher training systems, digital learning environments, and leadership practices in schools. However, this theme has evolved as an institutional change strategy that supports school adaptation and long-term sustainability in the digital education era.

4.4 Implications of Findings and Recommendations

From a theoretical perspective, these findings position training management within the broader transformation of school organizations. Training is no longer understood solely as a technical effort to improve technology use. The literature demonstrates strong links between digital leadership, teacher competence, and school culture transformation (Karakose et al., 2021; Zhang et al., 2025). This study highlights the need for an integrative and sustainable model of innovation-oriented training management in schools. Future theoretical models should integrate four key dimensions: school leadership, training design, educators' digital competence, and institutional governance. In addition, the model should incorporate the development of teachers' character, including spiritual values, professional ethics, and multicultural awareness. Such an integrated framework can explain how training functions as a mechanism of strategic organizational change rather than merely an individual capacity building initiative.

From a practical perspective, schools should design training within medium- and long-term strategic frameworks. Programs should extend beyond platform mastery and include structured mentoring, impact evaluation, and alignment with institutional strategic plans. Evidence from blended learning and online professional development studies showed that institutional support and active leadership strongly influenced successful implementation (Almusharraf & Khahro, 2020; Trust & Horrocks, 2017). Teacher training programs should

emphasize continuous professional development that integrates pedagogical, digital, and ethical competencies. Training should also support the effective use of digital classrooms through interactive and student-centered learning approaches. In addition, LMS design should include adaptive learning features, data-driven feedback, and user-friendly interfaces to improve instructional effectiveness. School management should therefore establish clear performance indicators for training, develop internal communities of practice, and allocate dedicated resources for digital literacy and technology leadership development.

Recent thematic shifts also highlighted growing attention to digital leadership, artificial intelligence-based competencies, and sustained institutional transformation. Future research agendas may include: (1) empirical studies examining the influence of principals' digital leadership on the effectiveness of artificial intelligence-based teacher training; (2) longitudinal research assessing the impact of digital training programs on school culture and student performance; (3) development and testing of integrated training management models that combine artificial intelligence, mentoring, and data-driven evaluation; and (4) cross-national comparative studies on strategies to strengthen teachers' digital competencies across diverse policy contexts.

Future studies should also examine how training models can integrate technological innovation with character development and inclusive educational values. These research directions can deepen understanding of how schools strategically manage innovation-oriented training within the digital education ecosystem.

5. Conclusion

This study aimed to map publication trends, principal reference sources, collaboration patterns, and thematic developments in innovation-oriented training management research in schools during the digital education era. The novelty of this study lies in framing innovation-oriented training management as a unified and strategic research domain. This approach moves beyond fragmented perspectives on leadership, professional development, or technology integration. The findings showed that scientific production increased significantly after 2022 and reached its peak during 2024–2025.

This growth reflected the acceleration of post-pandemic digital transformation. It also highlighted the increasing need to strengthen technology leadership, teachers' digital competence, and innovation-based training design. The publication landscape revealed the prominence of several journals that consistently addressed sustainable professional development, digital leadership, and technology integration in school systems. Influential documents in this field generally link training initiatives with institutional support, governance structures, and broader organizational transformation strategies.

From a thematic perspective, research evolved through several phases. In the early phase, studies primarily focused on technology integration and the effectiveness of learning platforms. Attention then shifted toward systematic,

evaluative, and quality-oriented training design. In the most recent phase, scholars positioned training management as a comprehensive digital transformation strategy. This phase emphasized school leadership, digital organizational culture, and competencies related to artificial intelligence. Patterns of international collaboration showed strong participation from countries with established research capacity, alongside growing contributions from Asia and Africa.

Overall, global trends indicated a transition from a technical orientation toward a strategic approach to managing innovative training in schools. This study implies the need for an integrative and sustainable training management model. The model should combine digital competence, leadership, institutional governance, and character development, including spiritual values, professional ethics, and multicultural awareness. From a pedagogical perspective, effective teacher training should integrate digital, pedagogical, and ethical competencies. This integration should be supported by adaptive and data-driven learning environments, including digital classrooms and LMS.

This study has several limitations. The analysis relied on a single database, which may have excluded relevant publications not indexed in that source. In addition, the study applied bibliometric analysis and network visualization without incorporating systematic qualitative synthesis, such as a systematic literature review. In terms of the digital education agenda, future research should examine the effectiveness of integrative training management models across contexts. This includes their impact on teacher performance, school culture, and student outcomes. Further studies are also needed to explore LMS-based training, digital leadership practices, and data-driven decision-making in supporting innovation-oriented training. Future research should expand database coverage and integrate bibliometric techniques with qualitative synthesis methods. Such an approach would provide deeper insight into the substance, methodological rigor, and practical implications of empirical findings in this field.

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Conflict of Interest

The authors declare that no conflicts of interest exist regarding the preparation, authorship, and publication of this study.

7. Declaration on the Use of Artificial Intelligence

The authors disclose the use of artificial intelligence (AI)–based tools in the preparation of this manuscript to enhance linguistic quality and textual coherence. ChatGPT (version 5.2) was used to support sentence refinement and improve readability. The tool was not applied to data analysis, interpretation, or the generation of research results. All AI-assisted content was carefully reviewed and revised by the authors to ensure accuracy, relevance, and contextual consistency. In addition, Grammarly was employed to assist with grammar checking and language editing.

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