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Digital Teaching Innovation in Education: A Systematic Review

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Abstract. Amid rapid digital transformation in education, the framework for digital teaching innovation is fragmented, with inconsistent evidence of its mechanisms. This study, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, reviewed 43 empirical studies published between 2021 and 2025. After screening for clarity and rigor, it analyzed data on definitions, determinants, and strategies. The study concluded that digital teaching innovation is a systemic transformation, integrating advanced technology with redesigned teaching methods. Key determinants include technological infrastructure, teacher capabilities, and student and organizational environments. This review identified five pathways to boost teacher innovation: fostering innovative thinking, merging technology with teaching and subject knowledge, using student-centered methods, enhancing professional collaboration, and aligning the institutional ecosystem. While Technological Pedagogical Content Knowledge and Substitution, Augmentation, Modification, Redefinition models guide practice, most efforts focus on enhancement. To advance digital teaching innovation, invest in infrastructure, teacher skills, and leadership. Recommendations include: (1) creating discipline-specific professional development for Technological Pedagogical Content Knowledge integration; (2) addressing digital infrastructure equity; (3) implementing distributed leadership and collaboration; and (4) evaluating beyond technology use to include learning outcomes.

Keywords: digital teaching innovation; sustainable digital transformation; systematic review; technology-enhanced learning

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1. Introduction

As institutions adopt advanced technologies, education is undergoing rapid digital transformation (Mukul & Büyüközkan, 2023). This transformation facilitates the diversification of teaching resources, personalization of learning experiences, and creation of interactive environments, thereby enhancing both student outcomes and teaching quality (Xu, 2023). Digital teaching innovation has emerged as a pivotal force driving educational reform and quality enhancement across various educational contexts (Wang et al., 2024). Against this backdrop, digital teaching innovation has become a pivotal driver of reform and quality enhancement (Wang, 2024).

In this review, digital teaching innovation transcends the mere adoption of new tools; it involves the creative integration of technologies–such as virtual reality (VR), artificial intelligence (AI), mobile learning platforms, and e-learning systems–into pedagogical strategies designed to enhance student engagement, foster critical thinking, and support lifelong learning (Ali-Rubaie, 2024). Early classroom experiences with generative AI suggest perceived gains in differentiation and efficiency, reinforcing the point that organizational and human factors are as critical as the tools themselves (Ampo et al., 2025a). This process also relies on the enhancement of teachers' innovative capacities, provision of institutional support mechanisms, and establishment of enabling policy environments (Huynh et al., 2024).

For digital education to be effective, it must offer immersive and interactive experiences that promote creativity, problem-solving, and adaptability, rather than merely transmitting knowledge (Wu, 2022). However, the implementation of digital innovation in education faces significant challenges. Technical and infrastructural limitations, including digital divides and unreliable internet connectivity, continue to be substantial barriers, particularly in underserved regions (Mexhuani, 2024).

In rural higher-education contexts, students' lived experiences with blended learning reveal unreliable internet access, high data costs, power outages, and weather-related disruptions that depress engagement and widen learning gaps, underscoring the need for context-responsive designs and supports (Ampo et al., 2025b). Even when specifically examining teacher innovation, existing reviews highlight conceptual ambiguities, methodological deficiencies, and a need for more robust theoretical foundations and clarity regarding outcomes (Liu et al., 2024).

Taken together, the identified opportunities and constraints underscore the necessity of a comprehensive review that synthesizes existing conceptualizations of digital teaching innovation while elucidating the mechanisms influencing its successful implementation across various educational environments. This review, therefore, amalgamated theoretical perspectives and empirical data from a range of educational contexts to clarify foundational concepts and highlight practical approaches. Consequently, this review was organized around the following research questions:

1. How is digital teaching innovation defined within the educational field?
2. What critical factors affect its implementation?
3. What strategies can enhance teacher innovation amid education's digital transformation?

2. Method

The present study used a Systematic Literature Review methodology in accordance with the guidelines established by PRISMA. The PRISMA framework is esteemed for its role in augmenting the quality and transparency of systematic reviews through a structured reporting approach. This approach includes the formulation of precise research questions, execution of an exhaustive literature search, and implementation of stringent procedures for study selection and data synthesis (Page et al., 2020). To capture the most recent advancements in digital pedagogy, particularly those influenced by the post-pandemic acceleration of educational digital transformation, this review concentrated on publications from 2021 to 2025. This time frame ensured that literature reflects the latest practices and challenges arising from the rapid global transition toward technology-enhanced learning.

A two-stage search strategy was employed. In the first stage, comprehensive searches were conducted across three major academic databases: Scopus (broad coverage across disciplines), Web of Science (high-quality, high-impact studies), and ProQuest Education Database (disciplinary depth and gray literature). Keywords or abstracts included 'digital teaching', technology-enhanced teaching', 'online teaching', ICT in education', combined with 'innovation', 'pedagogical innovation', and 'instructional innovation' and 'education', 'higher education', or 'vocational education'. This initial search yielded 861 publications. After duplicates were removed, 539 records remained for screening. Titles and abstracts were assessed against the inclusion criteria.

A total of 323 records were excluded based on criteria such as publication type (e.g., literature reviews, book chapters), publication date (before 2021), language (non-English), or irrelevance to the educational context. This exclusion process resulted in 216 articles being considered for retrieval. To ensure synthesis reliability, studies that passed initial screening underwent a qualitative review of research clarity, data transparency, finding credibility, and reporting adequacy. Two reviewers independently evaluated each study, resolving any disagreements through discussion. Studies lacking essential methodological details or rigor were excluded. After a comprehensive full-text screening, 181 articles were excluded due to insufficient empirical evidence or methodological reporting. As a result, 35 articles were retained in the initial stage.

In the second stage, backward citation tracking identified eight additional empirical studies, totaling 43 articles for analysis (see Appendix 4). We systematically extracted key data (author, year, country), digital technology type, and findings on technology-enhanced teaching and learning outcomes using predefined tables. The data were organized into comparable categories for synthesis. The modest final sample size was due to strict inclusion criteria, the

post-pandemic timeframe, and the limitation to English-language publications, ensuring focus and comparability. Figure 1 (PRISMA flow diagram) illustrates this process.

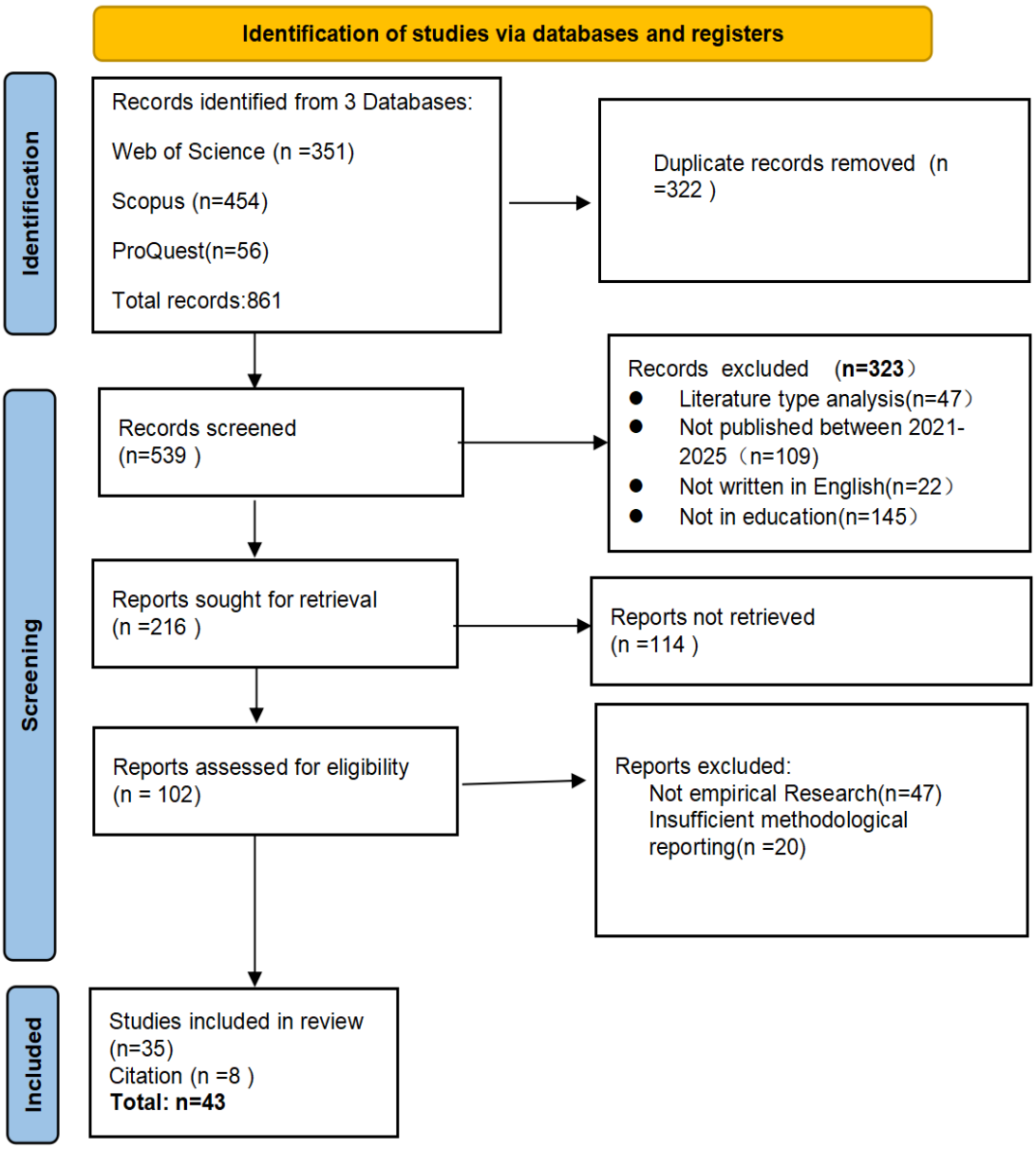

Figure 1：PRISMA flow diagram

3. Results and Discussion

3.1 Definition of Digital Teaching Innovation in Education

Over the past two decades, the concept of digital teaching innovation has undergone significant evolution. Initially characterized by a narrow, tool-oriented perspective that equated innovation with the adoption of platforms and multimedia resources (Choi-Lundberg et al., 2023), it has now transitioned toward a comprehensive systemic transformation. This transformation encompasses the

reshaping of pedagogy, instructional design, and institutional strategy (Akhmedova, 2024; Scott & Smith, 2024). Rather than perceiving technology as an external addition, this contemporary perspective emphasizes digital teaching innovation as an integrated process aimed at reconfiguring teaching and learning for the digital age.

The Technological Pedagogical Content Knowledge (TPACK) framework and the SAMR model provide critical conceptual underpinnings for this transition. TPACK highlights the dynamic interplay among technology, pedagogy, and content, emphasizing that innovation necessitates a harmonious integration of these three domains within specific contexts (Schmidt et al., 2017). Conversely, the SAMR model delineates the stages of technology integration, ranging from basic substitution to advanced modification and redefinition, wherein pedagogy undergoes significant transformation (Sholeh et al., 2024). Together, these models underpin the four-dimensional framework—comprising technology, teacher, student, and organizational environment—used in this review by linking micro-level classroom practices with systemic changes (see Figure 2).

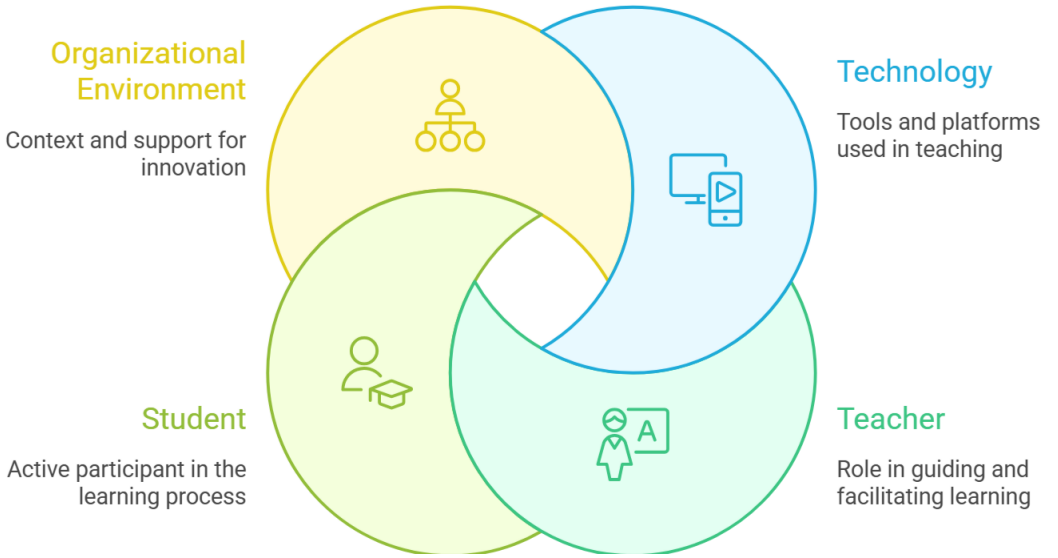

Figure 2: Four-dimensional framework of digital teaching innovation

From a technological perspective, numerous studies conceptualize digital teaching innovation as the intentional integration of advanced technologies—such as AI, virtual and augmented reality (VR/AR), adaptive learning systems, and data-driven analytics—into educational processes to enhance instructional delivery and learner engagement (Siyabonga et al., 2023). Within this framework, innovation involves the creation of immersive, interactive, feedback-rich environments that improve performance, simulate real-world scenarios, and expand access to educational opportunities (Hutasuhut & Harahap, 2024; Mthembu et al., 2023). However, definitions that focus exclusively on technology risk viewing innovation as an external enhancement rather than an intrinsic transformation of pedagogy, assessment, and learning culture (Napitupulu et al., 2024).

An alternative line of research underscores the significance of teacher-led pedagogical transformation (Gampala, 2023; Napitupulu et al., 2024; Tran Dong et al., 2024). In this context, digital teaching innovation is understood as educators' ability to creatively integrate emerging technologies with novel instructional strategies to foster critical thinking, creativity, and lifelong learning skills (Tran Dong et al., 2024; Gampala, 2023). This perspective highlights the evolving role of teachers from mere content delivery to facilitators of enriched learning experiences (Napitupulu et al., 2024; Tran Dong et al., 2024). In this context, innovation requires not only technical expertise but also interdisciplinary collaboration, reflective practice, and adaptability to the diverse needs of learners (Tran Dong et al., 2024).

Furthermore, the student aspect of digital teaching innovation highlights learners as active co-constructors of knowledge (Zhang et al., 2023; Chauca et al., 2021; Wang & Wu, 2022). This innovation entails a shift toward student-centered, personalized, and competency-based learning models, which enable learners to take greater responsibility for their educational pathways (Zhang et al., 2023). Research highlights the importance of digital environments in supporting differentiated instruction, peer collaboration, and self-directed learning, thereby fostering deeper engagement and the development of transferable skills (Chauca et al., 2021; Wang & Wu, 2022).

Moreover, the organizational environment provides the structural and cultural foundations essential for fostering teaching innovation (Scott & Smith, 2024; Zhang et al., 2024). Key factors such as institutional leadership, policy support, resource allocation, and collaborative networks play a critical role in determining the extent to which digital teaching practices can be effectively scaled and sustained over time (Scott & Smith, 2024). Research indicates that organizational readiness, encompassing infrastructure, professional development, and change management, is a vital enabler of meaningful innovation (Zhang et al., 2024).

Upon synthesizing various perspectives, three defining characteristics consistently emerge within the literature: (1) the integration of advanced digital technologies to enhance teaching effectiveness and learner engagement (Hutasuhut & Harahap, 2024); (2) the transformation of pedagogy toward active, personalized, and student-centered learning (Napitupulu et al., 2024); and (3) the systemic alignment with institutional goals and broader educational outcomes, supported by organizational culture and policy frameworks (Scott & Smith, 2024).

Building upon this synthesis, the current review conceptualized digital teaching innovation in education as a comprehensive and dynamic process. This process entails the strategic integration of emerging digital technologies with innovative teaching frameworks by teachers, students, and institutions. The aim is to enhance teaching effectiveness, promote active and personalized learning, and align educational outcomes with the evolving needs of society and the professional landscape (See Appendix 1). This review found that contemporary definitions converge on technology integration, pedagogical redesign, and institutional alignment. It provides a conceptual foundation for examining how these elements

interact to shape sustainable teaching innovation across diverse educational contexts.

3.2 Critical Factors Affecting the Implementation and Impact of Digital Teaching Innovation

While the definition of digital teaching innovation has become increasingly well-articulated, its translation into sustainable educational practice is neither linear nor automatic. Rather, it is contingent upon a constellation of interrelated factors operating across four primary domains: technological infrastructure, teachers' capacity, students' readiness, and organizational environment. These interact dynamically, shaping both the adoption process and the long-term impact of digital innovation.

The foundation of digital teaching innovation is fundamentally dependent on the availability and quality of technological infrastructure. Essential components such as reliable internet connectivity, robust learning management systems, and up-to-date hardware and software are prerequisites for the successful adoption of innovative teaching methodologies (Benfarha et al., 2024). Insufficient infrastructure remains a frequently cited barrier, particularly in under-resourced or developing contexts (Okoye et al., 2022). Beyond mere access, considerations of equity are crucial; disparities in technological resources across institutions, regions, or student demographics pose a risk of exacerbating educational inequalities and limiting the scalability of digital innovation (Amjad et al., 2024).

Furthermore, the adaptability and interoperability of technological ecosystems–such as platforms that integrate AI-driven analytics or support immersive VR/AR content–are critical in determining the extent to which educators can seamlessly incorporate these tools into pedagogical frameworks (Siyabonga et al., 2023). Issues of data security, privacy protection, and the availability of high-quality digital resources also significantly influence institutional trust and user confidence (Zhao et al., 2023). Thus, infrastructure is not merely a technical concern but a multifaceted issue with profound implications for educational equity and innovation.

Teacher competence serves as the cornerstone of successful digital teaching innovation. This competence encompasses not only technical skills but also pedagogical expertise and the strategic integration of digital tools with specific learning objectives (Althubyani, 2024; Nascimento et al., 2023; Hamzah & Ishak, 2024). Key factors facilitating the development of this competence include professional development, access to technology, and continuous support structures (Althubyani, 2024; Nascimento et al., 2023). Recent research indicates that while teachers generally exhibit moderate digital competence and a readiness to incorporate digital tools, there is considerable variability, often linked to contextual differences in institutional support and training opportunities (Hamzah & Ishak, 2024).

Teachers' beliefs and attitudes toward technology are equally critical; a mindset oriented toward growth, openness to experimentation, and student-centered pedagogical values facilitate creative and innovative teaching practices

(Mayangsari et al., 2025). Conversely, technophobia or a rigid adherence to traditional methods can impede innovation (Nascimento et al., 2023). Although extrinsic motivators hold significance, intrinsic motivators–such as professional growth, intellectual curiosity, and a commitment to student success–are more strongly linked to sustained engagement in innovation (Kottmann et al., 2024).

The efficacy of digital teaching innovations is significantly influenced by students' readiness, which includes their digital literacy, motivation, and access to technology (Polat, 2024). High levels of readiness, characterized by proficient digital skills, positive learning attitudes, and strong motivation, enable learners to derive greater benefits from innovative educational formats such as University 4.0 models, blended learning, and flipped classrooms (Jugembayeva & Murzagaliyeva, 2022). However, the prevailing assumption that "digital natives" are inherently prepared for digital learning is increasingly contested; many students still lack the critical, productive, and evaluative digital skills essential for meaningful engagement with new technologies (Polat, 2024).

Leadership and organizational climate play a critical role in influencing digital teaching innovation. Robust digital and distributed leadership models foster trust, empower faculty, and encourage experimentation with digital pedagogies (Gabutan et al., 2024; Laufer et al., 2024; Yuan & Khan, 2024). In contrast, leadership that delegates digital transformation responsibilities without adequate resources or support is often met with resistance and disengagement (Laufer et al., 2024). A positive organizational climate, characterized by collaboration, open communication, and a shared vision, enhances the effects of leadership (Anwar & Saraih, 2024; Gabutan et al., 2024).

This review found that the interplay among technology, teacher, student, and organizational climate conditions affects both adoption and outcomes (See Appendix 2): first, the mutual interdependence among technological, human, and organizational factors, which rarely function in isolation and whose alignment is essential for sustainable innovation; second, the dynamic influence, where factors affecting initial implementation may differ from those sustaining long-term impact; and third, the understanding that successful digital innovation relies not only on resources but also on the ongoing cultivation of digital competence, motivation, and leadership at multiple levels. The subsequent section addresses this question by examining strategies for empowering teachers through professional development, institutional support, and pedagogical innovation.

3.3 What Are the Strategies to Enhance Teacher Innovation in Digital Transformation in Education?

Although digital infrastructure, student readiness, and organizational climate provide the necessary conditions, the core of sustainable digital transformation ultimately depends on teachers' ability to innovate pedagogically with digital tools (Kowalczuk, 2023). Teacher innovation in digital teaching encompasses not only the adoption of new technologies but also the reimagining of instructional design, classroom interaction, and assessment practices in ways that fundamentally transform learning (Kocasaraç & Ndlovu, 2024). Therefore,

enhancing digital teaching innovation requires strategies that empower teachers as active agents of change rather than passive recipients of technological solutions (Javed, 2024).

3.1.1 Cultivating an innovative mindset

Research indicates that a defining characteristic of digital teaching innovation is teachers' willingness to experiment, reflect, and learn from failure (Dhakal, 2023; Elsayary, 2025). Engaging educators in structured reflective practices—such as through professional development programs or STEAM training—significantly enhances their design thinking mindsets, creative confidence, and capacity to navigate uncertainty. Iterative reflection enables teachers to adapt instructional strategies and design real-world problem-solving tasks, thereby embedding innovation into their daily teaching practices (Elsayary, 2025).

The transition to online teaching during the pandemic underscored the necessity for teachers to adapt and innovate within their pedagogical approaches. Educators who embraced digital tools and methodologies were able to transform their instructional practices, thereby illustrating the critical role of reflection and experimentation in fostering digital teaching innovation (Aldahdouh et al., 2023; Kallunki et al., 2023). The professional identity and reflexivity of educators are pivotal in facilitating their adaptation to online teaching environments.

The shift to online instruction has necessitated that teachers critically examine their experiences and reconstruct their professional identities, thereby exemplifying the evolving nature of pedagogical innovation (Vidergor, 2023). These findings underscore the significance of educators' readiness to engage in experimentation, reflection, and learning from setbacks as essential attributes of digital teaching innovation.

3.1.2 Integrating technology with pedagogical and disciplinary knowledge

The integration of digital tools with pedagogical models and disciplinary epistemologies is increasingly acknowledged as a pivotal element in advancing teacher innovation (Santos et al., 2024). This approach ensures that technology is not simply an adjunct but is thoroughly embedded within the educational framework, thereby promoting meaningful learning experiences. Such integration is underpinned by contemporary learning theories, including constructivism and connectivism, which highlight the significance of knowledge distribution through digital networks (Ulla et al., 2024).

By integrating digital tools with pedagogical models and disciplinary epistemologies, educators can promote deeper learning, enhance student engagement, and drive significant educational transformation. This approach encourages educators to reevaluate both content and methodologies, fostering epistemic change and sustainable innovation (Dhakal, 2023; Flores-Chacón et al., 2023). In contrast, when digital tools are used merely as supplementary elements, they often replicate traditional practices without leveraging the transformative potential of technology, leading to limited pedagogical innovation and minimal impact on student learning (Fowler & Leonard, 2021). The review demonstrated

that embedding digital technologies within the educational framework can significantly enhance teaching practices and learning outcomes.

3.1.3 Reconceptualizing pedagogical practices through active and student-centered learning

The incorporation of innovative digital teaching methodologies is increasingly acknowledged as a pivotal factor in advancing active, participatory, and student-centered pedagogies. Such methodologies frequently include project-based, collaborative, and experiential learning approaches that actively engage students in the educational process, thereby enhancing autonomy, critical thinking, and problem-solving abilities (Burke et al., 2024; Dhakal, 2023).

Digital pedagogies transition the emphasis from teacher-directed instruction to student-driven learning, enabling learners to progress at their own pace, make informed choices, and engage in reflective practices. This paradigm shift empowers students to assume responsibility for their learning and fosters deeper engagement (Ciolan & Manasia, 2024). Furthermore, these pedagogical approaches are linked to the enhancement of social, emotional, and cognitive competencies, such as collaboration, creativity, communication, and self-regulation, which are crucial for learners in the 21st century (Dhakal, 2023).

3.1.4 Embedding professional collaboration and co-creation

The integration of professional collaboration and co-creation within educational environments is increasingly acknowledged as a significant driver of innovation among educators. The principal argument posits that teachers are more effective in their innovative practices when they engage in collaborative efforts with peers, students, and technologists, a notion supported by an expanding corpus of research (Azaoui & Boumahdi, 2023; Çoban & Atasoy, 2020; Xafakos et al., 2020). This collaborative framework not only enriches the educational experience but also cultivates an atmosphere that promotes ongoing professional development and innovation (Azaoui & Boumahdi, 2023). Collaborative networks, both within and between schools, contribute to fostering an innovative climate and enhancing individual teacher innovativeness (Xafakos et al., 2020).

To transcend superficial collaboration and attain substantive innovation, it is essential to allocate adequate resources, and opportunities for professional development (Çoban & Atasoy, 2020). The significance of cultivating collaborative skills through team science-based training is underscored by its potential to markedly improve the effectiveness of multidisciplinary research teams (Pan et al., 2024). This evidence indicates that nurturing a collaborative culture among educators, students, and technologists can result in more innovative and impact educational practices. Leadership practices that emphasize distributed decision-making and professional autonomy are associated with higher levels of teacher engagement in innovation (Permyakov & Pavlova, 2021). Digital transformation and blended learning environments facilitate flexible, scalable professional development and classroom innovation (Zhao & Yang, 2024).

This review found five reinforcing pathways to strengthen teacher innovation (See Appendix 3). When analyzed through the TPACK framework, the majority of reported practices exhibit robust Technological Pedagogical Knowledge but only partial integration with Content Knowledge and Pedagogical Content Knowledge. The most significant advancements occur when professional development initiatives explicitly align disciplinary epistemologies with digital pedagogies, facilitating progress toward comprehensive TPACK.

According to the SAMR model, the prevalent pattern is situated at the augmentation/modification levels, with instances of redefinition occurring when the redesign of assessments, collaborative structures, and institutional support enables tasks that were previously inconceivable. This analysis elucidates why proficiency at the tool level seldom leads to scalable impact and highlights the necessity of supportive organizational conditions to complement teacher-led innovation.

4. Conclusion

This review elucidated that digital teaching innovation constitutes a comprehensive and multi-tiered transformation, rather than merely a technological enhancement. The literature consistently highlights three defining characteristics: the integration of advanced technologies to augment learning, the reconfiguration of pedagogy toward active and student-centered models, and the alignment of institutional ecosystems to sustain innovation. Concurrently, the effective implementation of such innovation is dependent on four interrelated domains: technological infrastructure, teacher competence and motivation, student readiness, and organizational leadership and climate.

The findings highlight several gaps: fragmented conceptual definitions needing unified models like TPACK and SAMR; limited research on how digital competence, motivation, and organizational climate connect, despite teachers' key role in transformation; and insufficient examination of student digital literacy and engagement, with a need for focus on equity and inclusivity. The review stressed the importance of enhancing teachers' digital teaching innovation for sustainable educational transformation. Future research should integrate theories like Self-Determination Theory and Organizational Innovation Climate with empirical studies across various contexts to build a comprehensive framework for global digital teaching innovation.

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Appendix 1: Table of Definitions of Digital Teaching Innovation across Four Dimensions

Author	Item	Definition	Purpose	Element			
				Technology	Teacher	Student	Organizational Environment
Siyabonga et al. (2023)	Technological	Technology plays a significant role in transforming teaching methods and addressing challenges.	Teaching practices Educational outcomes	√	√	×	√
Hutasuhut & Harahap (2024)	Technological	Digital technology is crucial for teaching innovation and enhancing traditional education.	Teaching Learning outcomes	√	√	√	√
Gampala, M. (2023)	Teacher	Integrate technology with pedagogy, shifting teachers' roles from traditional instruction to facilitators and instructional designers.	Critical thinking Lifelong learning	√	√	√	×
Tran Dong et al. (2024)	Teacher	The key to digital teaching innovation lies in improving teachers' digital literacy.	Professional Digital Resources Learners	√	√	√	×
Chauca et al. (2021)	Student	Problem-based digital teaching innovations can enhance student motivation, engagement, and deepen understanding.	Active Personalized Competency-Based Learning	√	√	√	×
Wang & Wu (2022)	Student	Disruptive teaching method innovations based on active activities and achieved through digital transformation.	Collaboration Peer Learning	√	√	√	×
Scott & Smith (2024)	Organizational environment	Digital teaching innovation is driven by collaboration among like-minded colleagues at the organizational level.	Originality Scale Value	√	√	×	√
Zhang et al. (2024)	Organizational environment	A positive organizational climate not only directly promotes teaching innovation but also indirectly achieves this goal by improving teaching effectiveness	Teaching Effectiveness Organizational Environment	√	√	√	√

Appendix 2: Table of Critical Factors Influencing Digital Teaching Innovation

Author	Technology	Teacher	Student	Organizational Environment
Okoye et al. (2022)	✓ infrastructures and resources ✓ access to internet and digital platforms	*Training		
Amjad et al. (2024)	✓ online learning hardware facilities ✓ software environments	*Innovative teacher training *Teaching research methods *Two-line integration teaching model		
Althubyani （2024）	✓ needed equipment and digital technologies	*teachers' digital competence *positive perceptions toward using digital technologies	＊stimulate students' creative thinking	
Nascimento et al. (2023)		*Professional development *Peer collaboration *Beliefs and attitudes about technology		
Hamzah & Ishak （2024）		*Intrinsic motivation *Extrinsic motivation *Knowledge sharing		
Polat (2024)			＊Digital literacy ＊Self-regulation ＊Motivation	
Paudel & Shrestha (2024)			＊Creativity ＊Innovation training ＊Digital literacy	
Laufer et al. (2024)				＊Adequate resources ＊Leadership models
Anwar & Saraih (2024)				＊Organizational climate ＊Shared vision

Appendix 3: Table of Strategies to Enhance Teacher Innovation in Digital Teaching

Dimension	Strategy	Mechanism	Expected Outcome	Source
Mindset	Encourage reflection, experimentation, learning from failure	Professional identity reconstruction, design thinking training	Increased creativity and resilience	Dhakal, B. (2023); Elsayary, A. (2025); Aldahdouh et al(2023); Kallunki et al(2023); Vidergor (2023)
Pedagogical Integration	Combine digital tools with pedagogy & disciplinary knowledge	Use TPACK as framework, align with constructive approaches	Deeper learning & epistemic change	Ulla et al.,(2024) Flores-Chacón et al(2023) Fowler&Leonard (2021)
Student-Centered Practices	Adopt project-based, collaborative, experiential learning	Empower students as co-creators, enhance autonomy	Higher engagement & 21st-century skills	Dhakal, B. (2023) Ciolan&Manasia(2024)
Professional Collaboration	Build peer networks & co-creation platforms	Time/resources for team innovation, inter-school collaboration	Stronger innovative climate	Azaoui &Boumahdi (2023) Çoban & Atasoy(2020) Xafakos et al(2020)

Appendix 4: Table of Details of Final Literature

No	Author	Title	Country
1	Choi-Lundberg et al. (2023)	A systematic review of digital innovations in technology-enhanced learning designs in higher education	Australia
2	Akhmedova (2024)	Digitalization and pedagogy: the evolution of teaching theories in the 21st century	Uzbekistan
3	Scott & Smith (2024)	Innovation from necessity: digital technologies, teacher development and reciprocity with organizational innovation	UK
4	Siyabonga et al. (2023)	Challenges, opportunities, and prospects of adopting and using smart digital technologies in learning environments: An iterative review	South Africa
5	Hutasuhut & Harahap (2024)	The Influence of Technology in the World of Education	Indonesia
6	Mthembu, Nomasonto Goodness et al. (2023)	The Pedagogical Shift in the Emergence of Digital Technology: Transforming Teaching Practices	South Africa
7	Napitupulu et al. (2024)	Teacher Professional Development in the Digital Age: Strategies for Integrating Technology and Pedagogy	Indonesia
8	Gampala, M. (2023)	Innovative Aproaches to Teaching and Learning	India
9	Tran Dong et al. (2024)	Digital competence of lecturers and its impact on student learning value in higher education	Vietnam
10	Zhang et al. (2023)	Student-centered case-based teaching and online–offline case discussion in postgraduate courses of computer science	China
11	Chauca et al. (2021)	Disruptive Innovation in Active Activity-Based Learning Methodologies through Digital Transformation	Peru
12	Wang & Wu (2022)	Effects of Online Cooperative Learning on Students' Problem-Solving Ability and Learning Satisfaction	China
13	Zhang et al. (2024)	The Relationship between Organizational	China

		Climate and Teaching Innovation among Preschool Teachers: The Mediating Effect of Teaching Efficacy	
14	Benfarha et al. (2024)	E-Learning and Teaching Methods: Toward New Innovative Practices	Morocco
15	Okoye et al. (2022)	Impact of digital technologies upon teaching and learning in higher education in Latin America: an outlook on the reach, barriers, and bottlenecks	Mexico
16	Amjad et al. (2024)	Digital Equity and Accessibility in Higher Education: Reaching the Unreached	Pakistan
17	Zhao et al. (2023)	New challenges in mitigating climate change: Digital teaching for the sustainable development and innovation	China
18	Althubyani (2024)	Digital Competence of Teachers and the Factors Affecting Their Competence Level: A Nationwide Mixed-Methods Study	Saudi Arabia
19	Nascimento et al. (2023)	Teachers' digital competences: Concepts, models and challenges for the educational integration of technologies	Brazil
20	Hamzah & Ishak （2024）	The relationship between digital competence and teacher motivation to lead: a pilot study	Malaysia
21	Mayangsari et al. (2025)	Unraveling Intrinsic Motivation: The Key to Empowering Teacher Professional Growth	Indonesia
22	Kottmann et al. (2024)	Determinants of the Innovation Behavior of Teachers in Higher Education	Netherlands
23	Polat (2024)	Readiness, resilience, and engagement: Analyzing the core building blocks of online education	Turkey
24	Jugembayeva & Murzagaliyeva (2022)	Physics Students' Innovation Readiness for Digital Learning within the University 4.0 Model: Essential Scientific and Pedagogical Elements That Cause the Educational Format to Evolve in the Context of Advanced Technology Trends	Kazakhstan
25	Omeh et al. (2024)	Fostering computer programming and digital skills development: An experimental approach. Computer Applications in Engineering Education	Nsukka

26	Paudel & Shrestha (2024)	Students Engagement in Classroom Teaching by Innovative Pedagogy: A desk-based Review of Existing Literature	Nepal
27	Laufer et al. (2024)	Leading with Trust: How University Leaders can Foster Innovation with Educational Technology through Organizational Trust	Germany
28	Yuan & Khan (2024)	Investigating the impact of digital leadership on innovation performance of public universities in Yunnan, China	China
29	Gabutan et al. (2024)	School Heads' Leadership Quality, Organizational Climate, and Learning Environment as Predictors of Teachers' Innovativeness	Philippines
30	Anwar & Saraih (2024)	Digital leadership in the digital era of education: enhancing knowledge sharing and emotional intelligence	Malaysia
31	Dhakal, B. (2023)	Digital Pedagogy: An effective Model for 21st Century Education	Nepal
32	Elsayary, A. (2025)	Enhancing teachers' design thinking mindsets through reflective practice: Cultivating innovation in an upskilling STEAM training program	UAE
33	Aldahdouh et al. (2023)	University teachers' profiles based on digital innovativeness and instructional adaptation to COVID-19: Association with learning patterns and teacher demographics	Finland
34	Kallunki et al. (2023)	Comparison of voluntary and forced digital leaps in higher education - Teachers' experiences of the added value of using digital tools in teaching and learning	Finland
35	Vidergor (2023)	The effect of teachers' self-innovativeness on accountability, distance learning self-efficacy, and teaching practices	Israel
36	Ulla et al. (2024)	Becoming and being online EFL teachers': Teachers' professional identity in online pedagogy	Thailand
37	Flores-Chacón et al. (2023)	Educational innovation: the architecture of digital technologies as a catalyst for change in university teacher training	Peru

38	Fowler & Leonard (2021)	Using design-based research to shift perspectives: a model for sustainable professional development for the innovative use of digital tools	Australia
39	Burke et al. (2024)	Mediating learning with mobile devices through pedagogical innovation: Teachers' perceptions of K-12 students' learning experiences	Australia
40	Ciolan & Manasia (2024)	Picturing innovation in higher education: A photovoice study of innovative pedagogies	Romania
41	Azaoui & Boumahdi (2023)	Active pedagogy in university e-learning for the construction of Social and Emotional Skills	Morocco
42	Çoban & Atasoy (2020)	Relationship between distributed leadership, teacher collaboration and organizational innovativeness	Turkey
43	Xafakos et al. (2020)	The Effect of Teachers' Collaborative Networks on Innovative School Climate and Their Individual Innovativeness	Greece