

The Current Configuration of Teachers' Research Competences within Digital Culture for Pedagogical Innovation

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Abstract

The ongoing digital transformation of educational environments, driven by the widespread adoption of advanced information and communication technologies, has reconfigured the conditions of teachers' professional development and has foregrounded research competences as defining elements of epistemic responsibility, reflective practice, and transformative engagement in pedagogical practice. Within this context, digitally mediated spaces operate as complex environments that support professional growth, as educators move through interconnected networks of open-access resources, collaborative knowledge communities, and analytic infrastructures that sustain the generation, examination, and pedagogical use of evidence, while requiring ethical judgement, methodological awareness, and responsiveness to uneven access, variable technological proficiency, and institutional variability. The aim of this article is to conceptualize the configuration and development of teachers' research competences within these evolving digital environments, clarifying their epistemic, methodological, and professional significance for contemporary educational practice. Based on recent scholarship and established theoretical contributions, such as the Technological Pedagogical Content Knowledge framework, socio-constructivist approaches to collaborative inquiry, and UNESCO's guidelines on open and responsible science, this article presents teachers' research competences as a consolidated system of epistemic understanding, digital proficiency, methodological exactness, reflective orientation, collaborative participation, and transformative intent that strengthen professional autonomy and ability to make data-informed pedagogical decisions. The targeted competences are summarized in a *Digitalized Model of Teachers' Professional Identity* and support, at the process level, the *Conceptual Model of Educational Innovation Processes*. The development of these competences is shaped by institutional conditions, policy coherence, and ethically grounded engagement in wider knowledge networks, thereby enabling teachers to act as reflective practitioners, methodological contributors, and scholarly actors who generate, question, and apply knowledge in ways that support pedagogical innovation, deepen their professional identity, and support continuous educational renewal within digitally mediated contexts.

Keywords: teachers' research competences, digital culture, professional autonomy, reflective practice, methodological accuracy, ethical literacy, educational innovation.

Introduction

The rapid evolution of digital technologies in science and education has accelerated the development of practical skills that support learning, teaching, and research. Within contemporary educational transformations shaped by digital culture, pedagogical research operates as a strategic vector of educational rationality, informing both instructional decision-making and policy development. Positioned as an applied epistemological field, pedagogy integrates validated theoretical paradigms with socio-institutional and technological conditions. In a knowledge society driven by continuous learning and innovation, pedagogical research links theoretical advancement to practice, fostering institutional adaptability and supporting sustainable educational development (Boroza, 2020, pp. 120–121). These transformations require an integrated conceptual and methodological framework that integrates the normative aims of education with the imperatives of organizational and digital change.

UNESCO's efforts, particularly the UNESCO Recommendation on Open Science (2023), reflect a commitment to open, ethical, and technologically informed scientific practice. It promotes inclusivity and transparency, encouraging researchers to access, produce, and share knowledge in interoperable and responsible ways (UNESCO, 2023). The expansion of digital technologies demands new methodological flexibility and digital competences, prioritizing the development of researchers' ability to manage open scientific knowledge, including open data and shared infrastructures (Tomescu, n.d.). By establishing common standards, UNESCO frames digital transformation as a reconfiguration of how knowledge is produced, validated, and disseminated, strengthening both individual and institutional capacity for global scientific collaboration.

Digital culture also reshapes the processes of generating, validating, and circulating knowledge within education, extending the epistemological and methodological roles of pedagogical research. Universities are increasingly emerging as digital epistemic hubs where research, teaching, and innovation intersect (Boroza & Turcan, 2024). Within these environments, research enables faculty and students to develop investigative and reflective competences, using digital resources creatively and responsibly to cultivate institutional innovation grounded in scientific evidence.

The digitalization of education transforms teachers' professional identity, positioning them as researchers, innovators, and reflective practitioners. Research competences have become indispensable to professional development, enabling educators to design inquiry-based learning environments and contribute to knowledge creation. When anchored in coherent institutional strategies, digital technologies facilitate collaboration, broaden access to research, and strengthen teachers' ability to connect theory and practice. Teachers' research competences include navigating complex digital information environments, interpreting data ethically, participating in digital communities of practice, and translating evidence into responsive pedagogical action. These skills reinforce professional resilience and support sustained educational innovation (Boroza & Bushnaq, 2025b). Figure 1 portrays the digitalized teacher's professional identity as an integrated set of roles, in which teachers reflect on their practice, pursue innovative approaches, conduct systematic inquiry, and intentionally design meaningful learning experiences. The teacher's professional identity encompasses a *reflective practitioner*, who evaluates instructional strategies, analyzes

outcomes, and engages in continuous self-assessment to guide adaptive teaching; a *learning designer*, who creates inquiry-based, personalized learning experiences by integrating pedagogical theory, curriculum objectives, and digital tools; an *innovator*, who experiments with new methods, technologies, and evidence-based approaches to enhance teaching and learning; and a *researcher*, who engages in systematic inquiry, collects and interprets data, contributes to institutional development, and participates in collaborative research networks.

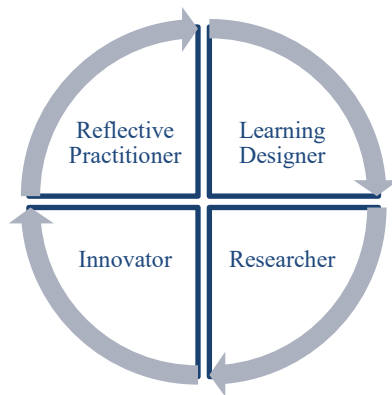


Figure 1. Digitalized Teacher Professional Identity Model

In this context, the present article investigates how digital culture shapes teachers' research competences and professional identity, recognizing persistent challenges such as digital inequality and ethical data use. The study proposes a multidimensional conceptualization of research competence grounded in the interaction between pedagogical inquiry and digital culture. The analysis synthesizes factors that enable or constrain teachers' research capacity in technologically mediated environments, treating competence as both a cognitive attribute and a socio-institutional construct. The article formulates interpretive propositions on the reconfiguration of research skills in the digital era, identifying essential indicators of competence formation within the broader context of digitalization, professional autonomy, and institutional innovation.

Methods and Materials

The study examined contemporary scholarship and institutional documents that explore the development of teachers' research competences within digitally mediated educational environments. Sources included journal articles, theoretical frameworks, policy documents, and institutional reports, with particular attention to works addressing digital pedagogy, professional development, and teachers' research capacities. Data extraction emphasized factors that enable or constrain research competence, models of professional learning in digital contexts, and indicators of epistemic, methodological, and ethical proficiency. The analysis followed an iterative process of thematic synthesis, integrating evidence to construct a multidimensional conceptualization of research competence grounded in the interaction between pedagogical inquiry and digital culture. Contextual factors such as institutional structures, policy frameworks, and technological infrastructure were considered to ensure that findings reflect both cognitive and socio-institutional dimensions of competence formation.

Results and Discussion

Digital technologies offer significant potential for transforming teacher learning and supporting professional development across the career span (Minea-Pic, 2020). Their use should advance the broader objectives of education systems. When appropriate enabling conditions are established, digital technologies can enhance quality, equity, and efficiency (OECD, 2023a, p. 24). As shown in Figure 2, these interrelated dimensions act as structural mechanisms sustaining educational quality, with the effective integration of technology fostering professional growth.

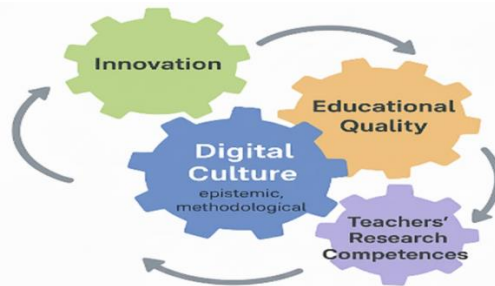


Figure 2. Digital Technologies as Enablers of Educational Quality

Digital technologies have transformed how knowledge and information are accessed, shared, and produced (UNESCO, n.d.-a). They function as integrative mediators, driving a dynamic digital culture that fosters innovation, enhances educational quality, and strengthens teachers' research skills. They constitute "networks of tools and programs that connect people and things across the world" (UNESCO, n.d.-b), reshaping the cognitive and methodological frameworks through which teachers generate and apply knowledge. By enabling collaborative exchange and reflective engagement, digital environments convert professional practice into an interactive process of inquiry and knowledge construction. Educational quality emerges as an evolving condition, shaped by teachers' ability to integrate technological mediation with intellectual autonomy, creative exploration, and methodological accuracy within their professional and research activity.

Within this digital culture, teachers routinely access online information, open educational resources, MOOCs, and professional communities to support inquiry, reflection, and shared meaning-making (Minea-Pic, 2020). Studies on digital education technologies in higher education likewise emphasize the role of online and blended environments in improving access, equity, and educational quality (OECD, 2023a, p. 27). In such environments, research competence is enacted through research literacy, digital literacy, data ethics, collaboration, and innovation, positioning educators as reflective practitioners, data-informed decision-makers, and co-creators of digital knowledge systems within digitally mediated professional practice.

In this context, the success of digital transformation in education, particularly in strengthening teachers' research competences and supporting pedagogical innovation, depends on the synergy of culture, strategy, and technology (Figure 3). A strong culture encourages flexibility, collaboration, digital fluency, and openness to risk, while also being supported by ongoing measurement and leadership engagement. At the same time, a clear strategy provides a shared vision, sets measurable goals (such as research objectives), defines governance processes, and guides how digital tools can reshape research practices.

Technology enables this transformation through strong infrastructure, cloud computing, APIs, automation, and analytics that help make sense of complex data.

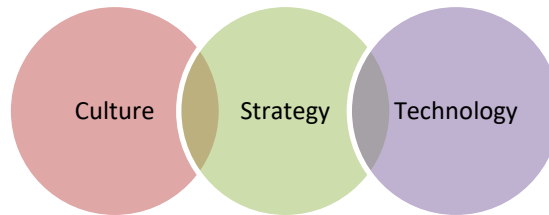


Figure 3. Digital Transformation Requirements

These elements provide the foundation upon which institutions can generate measurable benefits for teaching, learning, and research, as shown in Figure 4.

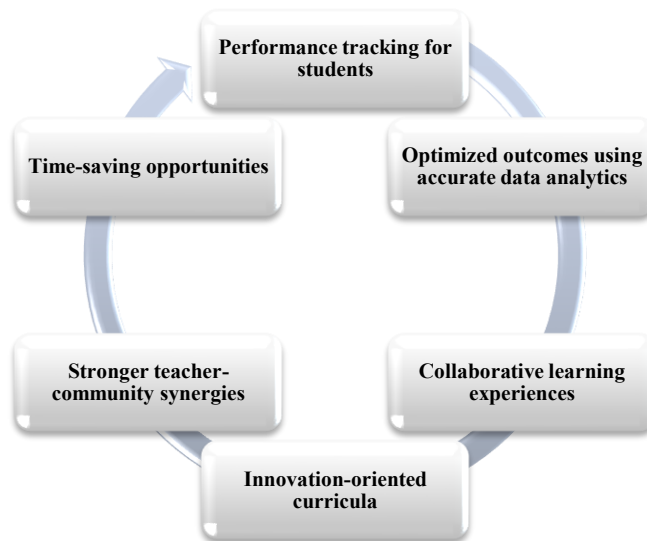


Figure 4. The Benefits of Digital Transformation in Education

This transformation is operationalized through the Conceptual Model of Educational Innovation Processes (Figure 5), which situates educational innovation at the intersection of three interrelated pillars: Knowledge Building, which generates evidence-informed insights validated through academic achievement and systematic evaluation while fostering collaboration through networking; Culture Building, which establishes the institutional conditions for innovation via Professional Learning Communities, purposeful academic leadership, and strategically deployed resources; and Pedagogical Innovation Skills, through which teachers, supported by expert guidance, create practical knowledge from reflective classroom practice.

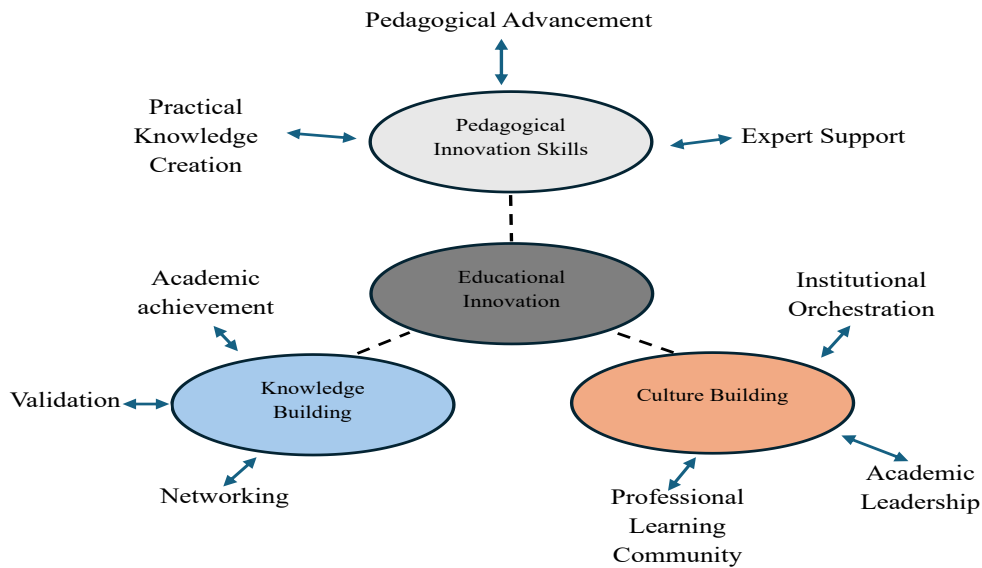


Figure 5. Conceptual Model of Educational Innovation Processes

Educational innovation represents a systemic process of intentional transformation of educational practices, aimed at improving the quality of learning, equity, and the relevance of education in relation to social, technological, and economic changes. From a theoretical perspective, educational innovation involves significant pedagogical change grounded in established learning theories (constructivism, socio-constructivism, experiential learning, situated learning), validation through evidence-based education, and a measurable impact on learning outcomes, rather than being limited to the introduction of isolated technologies, methods, or curricula. Educational research identifies multiple, interrelated dimensions of educational innovation operating at different levels: (a) curricular innovation, referring to the restructuring of content and targeted competences; (b) pedagogical innovation, referring to learner-centered methods such as problem-based learning, project-based learning, and the flipped classroom; (c) technological innovation, referring to the integration of digital technologies as cognitive environments; (d) organizational innovation, referring to new models of educational leadership and institutional culture; and (e) assessment innovation, referring to authentic, formative, competency-based assessment.

Pedagogical innovation skills represent an integrated set of advanced professional competences that enable teachers to design, implement, evaluate, and adapt effective and sustainable educational practices. From a pedagogical and educational sciences perspective, these competences are situated at the intersection of classical teaching competences, reflective competences, digital competences, and applied research competences (practitioner research), enabling the transformation of pedagogical knowledge into innovative practices adaptable to complex educational contexts. The categories of pedagogical innovation skills include *innovative pedagogical design competences*, encompassing the analysis of learners' real needs, the formulation of competency-based learning objectives, and the integration of active and learner-centered strategies; *implementation and experimentation competences*, involving the controlled testing of new methods, instructional flexibility, and real-time

adaptation based on educational feedback; *reflective and metacognitive competences*, including self-evaluation of pedagogical practice, critical reflection on outcomes, and learning from error as a professional resource; *competences for the pedagogical use of technology*, addressing the integration of technology as a learning environment, the design of authentic digital learning experiences, and the use of educational data for pedagogical decision-making; *innovative assessment competences*, referring to formative and authentic assessment, performance-based rubrics, and constructive, progress-oriented feedback; and *collaboration and educational leadership competences*, involving participation in communities of practice, curricular co-creation, and the dissemination and scaling of good practices.

Knowledge building is defined in the educational sciences and cognitive psychology as a collective and intentional process of creating, refining, and advancing knowledge, in which learning is conceived as a social process of continuous intellectual innovation rather than individual information acquisition. *Culture building* represents an intentional social process through which values, norms, practices, and shared meanings are created, shared, and consolidated over time, shaping how individuals think, learn, and act within educational communities. *Practical knowledge creation* refers to the generation of knowledge through experience, action, and reflection on practice, constituting a core mechanism for professional competence development, organizational innovation, authentic learning, and effective adult education.

The Organization for Economic Co-operation and Development (OECD, 2023a) frames the digitalization of education as a multidimensional and systemic transformation that fundamentally reconfigures how educational institutions operate, deliver instruction, and prepare learners. This transformation extends beyond the technical deployment of digital tools to encompass a comprehensive restructuring of the educational system, including pedagogical design, assessment practices, governance structures, and institutional culture. The OECD advocates an integrative systems framework in which digital integration occurs coherently across interconnected domains, including curriculum development, teacher preparation, infrastructure, and policy. Digitalization is understood as a long-term process requiring adaptive, cross-sectoral strategies that connect educational objectives with broader social, economic, and technological developments, while accommodating emerging technologies like artificial intelligence and upholding equity, inclusiveness, and ethical responsibility (OECD, 2023a).

From a sociocultural and communicative standpoint, digital culture is conceived as a constructed and continuously evolving phenomenon that mediates human interaction, cognition, and social organization within technologically networked environments (Köhler, n.d.). It functions simultaneously as a product and a generative force of social transformation, shaping how individuals and communities create meaning, exchange information, and participate in knowledge economies. Engagement with digital culture involves technical competence together with the symbolic and interpretive practices through which societies negotiate the effects of technological mediation. Extending this to higher education, digital culture is an evolving, value-based system encompassing the attitudes, norms, and competences that guide the use of digital technologies in educational, research, and social contexts (Grevtseva et al., 2022). Within professional practice, digital culture represents an integrative configuration of professional knowledge, technical competence,

and ethical orientation, requiring teachers to understand the epistemic foundations of digital technologies and employ them critically and effectively (Hermanson, 2023). Building on these perspectives, digital culture reshapes teachers' professional identity and autonomy by transforming the conditions under which pedagogical responsibility is enacted, fostering the reconstruction of professional selves through the development of digital identities, reflective adaptation, and innovation-oriented engagement (Li et al., 2023).

The increasing complexity of contemporary life requires individuals to understand the logic of exploring, harnessing, and transforming information. Higher education assumes responsibility for cultivating competences that facilitate professional advancement, personal fulfillment, and social participation (Coropceanu, 2021). The development of teachers' research competences thus emerges as a fundamental dimension of university education, enabling educators to generate, critically evaluate, and apply knowledge in ways that enhance pedagogical practice, foster educational innovation, and strengthen a culture of professional autonomy and evidence-informed decision-making. These competences can be conceptualized as a multidimensional construct encompassing cognitive, methodological, analytical, and reflective abilities that empower teachers to translate research into pedagogical innovation and sustained professional growth (Borožan & Bushnaq, 2025).

The systematic embedding of these competences within coherent educational policy frameworks is necessary. In this respect, the OECD (2023b) offers a comprehensive model (see Figure 3) that illustrates the structural and policy mechanisms guiding the development of teachers' digital competences within an integrated and sustainable structure.

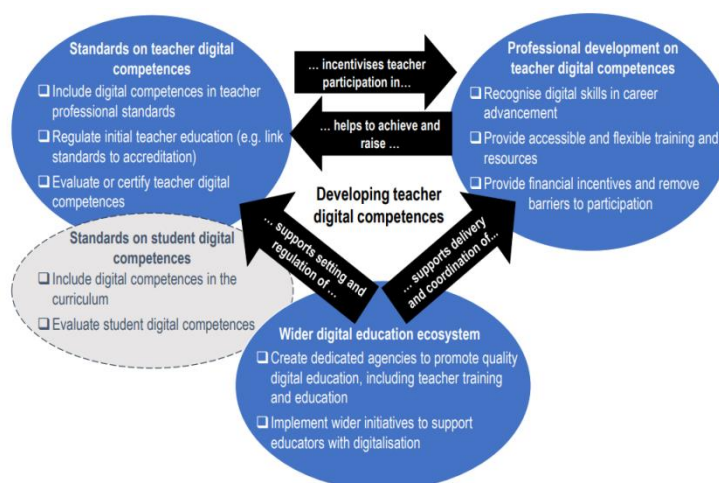


Figure 6. Approaches and policy levers to formalize the development of teacher digital competences (Source: OECD, 2023b).

As indicated in the OECD framework, the effective development of teachers' competences depends on the interrelation among four dimensions: *teacher standards*, *professional development*, *student digital competences*, and *the broader digital education landscape*. Applied to teachers' research competences, the OECD model suggests that research literacy and digital proficiency must be cultivated through integrated professional standards, strategic institutional support, and coordinated system-level actions, ensuring that teachers engage in reflective, research-informed practices within a digitally mediated culture of

innovation and collaboration. From this perspective, teachers' research competences underpin the systematic generation, critical evaluation, and practical application of knowledge, supporting continuous professional growth, deepening critical reflection, and contributing to collective pedagogical advancement (Borozan & Bushnaq, 2025).

The conceptual foundation of digital education as a facilitator of research competences is grounded in the Technological Pedagogical Content Knowledge (TPCK) framework (Mishra and Koehler, 2006), which extends Shulman's (1986) Pedagogical Content Knowledge (PCK). This framework articulates a dynamic epistemic relationship among content, pedagogy, and technology, proposing that effective teaching emerges from the integrated understanding of these components. Technology is positioned as an epistemological medium that reshapes both the representation of disciplinary content and pedagogical reasoning. Within the TPCK framework, digital education functions as an environment that enables and conditions the development of teachers' research competences, including the capacity to generate, evaluate, and apply evidence to improve pedagogical practice through inquiry-oriented and reflective processes. It broadens methodological repertoires by incorporating data-driven feedback systems, online collaboration platforms, and virtual research communities that support evidence-informed decision-making, while simultaneously reflecting constraints and ethical considerations (Mishra & Koehler, 2006).

Empirical research demonstrates that digital knowledge-sharing environments constitute essential infrastructure for developing research competences in higher education. Digital communities operate as socio-cognitive systems that foster pedagogical and technological innovation through collaboration, dissemination of effective practices, and experimentation (Huang et al., 2023). However, these environments reflect structural inequalities in infrastructure, access, and content quality, producing uneven opportunities for participation and professional growth (Gustafsson-Wright et al., 2022). Disparities extend beyond access to devices, encompassing variations in motivation, digital literacy, and the quality of institutional professional development (Soomro et al., 2020; Miras et al., 2023; Nagel & Amdam, 2025).

The integration of real-time digital tools establishes a feedback-oriented model of professional inquiry, facilitating the shift from passive information use to active interpretation of digital data, contingent upon institutional infrastructures that ensure reliability, ethical governance, and equitable access to analytical resources. Digital education thus functions as both an enabler and a regulator of teachers' research competences, providing epistemic tools and collaborative platforms while reflecting and reproducing social and institutional inequities. Developing these competences requires a coherent policy framework grounded in equity, sustainability, and epistemic responsibility.

Teachers' research competence in the digital era represents a synthesis of epistemic responsibility, methodological reflexivity, and technological mediation. It entails a disposition toward inquiry in which knowledge construction is conceived as a continuous negotiation among epistemological assumptions, methodological coherence, and the interpretive use of digital evidence. The teacher-researcher engages across the full trajectory of inquiry within digitally mediated environments structured by information systems (Rubio et al., 2018, cited in Guillén-Gámez et al., 2023). Digitalisation reconfigures the epistemic conditions of educational research by enabling data-driven reasoning and interpretive

analysis of digital artefacts (Guillén-Gámez et al., 2023). Data literacy emerges as an instrument extending methodological precision into algorithmic environments, and teachers' level of data competence predicts their ability to use digital information for analytical and pedagogical purposes (Michos et al., 2023; Lin et al., 2022). Digital environments operate as dynamic epistemic systems that integrate the processes of searching, interpreting, and communicating knowledge (Guillén-Gámez et al., 2024). Blended digital portfolios support meta-cognitive regulation, self-evaluative engagement, and dialogic reflection, transforming reflection into epistemological self-interrogation and enabling educators to integrate theoretical constructs with experiential insights (Chui et al., 2016; Novoa-Echaurren et al., 2023).

Collaboration and ethical competence are integral to research formation. Online professional networks create translocal spaces of co-construction, situating research as a distributed practice, while ethical competence addresses privacy, transparency, and data stewardship (Fütterer et al., 2024; Guillén-Gámez et al., 2023). Structured research activities, including scientific clubs and elective courses on research skills, reinforce intellectual autonomy, critical interpretation, and generative innovation. Digital and data fluency enable teachers to collect, analyse, and interpret evidence, engage with learning analytics, and communicate findings effectively (OECD, 2019, cited in OECD, 2020; Guillén-Gámez et al., 2023). Continuous engagement with digital portfolios, feedback systems, and data-informed decision-making, combined with collaborative participation in online professional communities, supports reflective practice, co-creation, and dissemination of knowledge (OECD, 2020; Yerzhanova et al., 2025). Guided by the principles of openness, inclusivity, and transparency outlined in the UNESCO Recommendation on Open Science (2023), teachers apply research findings to digital action research, experimental pedagogical practices, and the generation of new professional knowledge, positioning digitally competent teacher-researchers as agents of educational modernization and institutional innovation. Table 1 summarizes the main indicators and observable skills of teachers' research competence in the digital era, illustrating how epistemic, digital, reflective, collaborative, ethical, and transformative capacities are expressed in practice.

Table 1. Indicators of Teachers' Research Competence in the Era of Digital Culture

Indicators	Observable Skills
Epistemic and Methodological Awareness	• Formulates researchable problems situated within digital pedagogy and technology-mediated teaching • Selects and justifies digital, mixed, or hybrid methodological approaches appropriate to the research purpose • Observes ethical protocols in online data gathering, data security, and participant confidentiality • Integrates scholarly, institutional, and practice-based digital evidence into coherent analytical frameworks
Digital and Data Fluency	• Employs digital instruments for data generation, processing, interpretation, and representation • Critically appraises the reliability, relevance, and methodological robustness of online information sources

	• Interprets learning analytics to inform pedagogical reasoning and evidence-based conclusions • Communicates research insights through diverse digital formats and scholarly dissemination channels
Reflective and Analytical Disposition	• Uses digital portfolios, feedback systems, and self-evaluation tools to sustain reflective inquiry • Examines instructional practices through systematic analysis of digital records and learner data • Adjusts pedagogical strategies through iterative cycles of inquiry, triangulated evidence, and analytical judgment
Collaborative and Networked Engagement	• Participates in digital professional networks and research-oriented communities of practice • Engages in co-construction of knowledge using collaborative platforms and shared digital workspaces • Disseminates research results via webinars, institutional repositories, virtual symposia, and open scholarly forums
Ethical and Societal Responsibility	• Exercises informed ethical judgment in all phases of digital research practice • Advocates for inclusivity, equity, accessibility, and privacy awareness in technology-enhanced educational contexts • Promotes open, transparent, and responsible scientific practices aligned with contemporary academic standards
Transformative and Innovative Orientation	• Applies research outcomes to redesign instructional practices and advance digital pedagogy • Participates in digital action research, pilot testing, and experimental innovation cycles • Contributes to the development of new professional, pedagogical, and institutional knowledge through sustained inquiry

Guillén-Gámez, Ruiz-Palmero, and García (2023) argue that continuous professional formation is essential for strengthening teachers' digital proficiency and promoting constructive attitudes toward ICT in research contexts. Teacher training consolidates methodological precision, encourages ethical digital engagement, and reinforces institutional innovation.

Similarly, Yerzhanova, Autayeva, Mazhinov, Iralina, and Nishanbayeva (2025) show that targeted educational interventions, including elective courses on research skills and participation in scientific clubs, enhance students' ability to formulate research questions, select methodologies, analyze data, interpret findings, and increase confidence in applying scientific methods. Digital technologies hold significant potential for transforming teacher learning and professional development throughout their careers (Mineia-Pic, 2020). According to the OECD (2019, cited in Mineia-Pic, 2020), teachers' skills are essential for harnessing the pedagogical potential of emerging digital tools, as the digital divide has shifted from differences in Internet access to deeper inequalities in digital engagement

shaped by literacy, numeracy, problem-solving, and the ability to navigate technology-rich environments.

Conclusion

The current configuration of teachers' research competences, as highlighted in the work of contemporary scholars, indicates a progressive transition from traditional competences, such as documentation, theoretical analysis, and pedagogical reflection, toward digitally integrated competences required for investigating and innovating educational practices in technologized contexts. In this regard, digital culture significantly influences the ways in which teachers design, implement, and capitalize on pedagogical research, fostering the use of digital tools for the collection, analysis, and interpretation of educational data, as well as for the dissemination of research results. At the same time, a marked heterogeneity can be observed in the level of development of teachers' digital research competences, determined by professional experience, access to technological resources, initial and continuing professional education, and the degree of institutional support for pedagogical innovation.

For these theoretical reasons, research competences oriented toward pedagogical innovation are frequently associated with teachers' ability to integrate emerging digital methods, such as educational data analytics, design-based research, and technology-assisted assessment, into initiatives aimed at improving the teaching–learning process. The promotion of a reflexive digital culture contributes to strengthening the teacher's role as a practitioner-researcher, capable of using data generated by digital learning environments to substantiate pedagogical decisions and to adapt instructional strategies to learners' real needs.

An analysis of scientific contributions to the development of this field reveals that the advancement of research competences in digital contexts requires systemic approaches that integrate methodological training, advanced digital literacy, and research ethics in virtual environments. The effectiveness of digital education further depends on ethical awareness, institutional coherence, and equitable technological infrastructure, which require policies that integrate technological advancement with social justice and epistemic responsibility. Within the context of pedagogical innovation, teachers' research competences become a strategic vector of educational change, facilitating the transition from reproductive teaching practices to evidence-based practices, controlled experimentation, and digitally mediated collaborative learning.

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