

Received: 01-04-2026 | **Accepted:** 03-05-2026 | **Published:** 25-07-2026**DIGITAL COMPETENCY SHIFTS AMONG EDUCATORS:
DEVELOPMENTS, CHALLENGES AND OPPORTUNITIES****Devi Arhami Putri**

Universitas Islam Negeri Ar-Raniry Banda Aceh

Email: devi.putri@ar-raniry.ac.id**Abstract**

As the technological era has evolved, educational technology has transformed from the mere use of standalone devices into a key infrastructure for learning. This shift has also increased the demands placed on teachers' digital competences. This narrative review synthesises 30 years of literature (1996–2026) to map the development of theoretical frameworks and institutional definitions regarding educators' digital competences. This study traces the shift from operational skills in information and communication technology (ICT) towards pedagogical integration models such as TPACK and DigCompEdu, and on to a new paradigm focusing on generative artificial intelligence, data privacy, digital ethics and technology governance. The findings of the synthesis indicate that there remains a gap between teachers' technical proficiency and their ability to integrate technology effectively into pedagogical practice. The latest literature also highlights a number of unresolved issues, namely the predominance of self-assessment-based surveys over performance-based assessments, the limited adaptation of digital competences to specific subjects and educational contexts, and the scarcity of research on developing education systems. Consequently, policies and professional development programmes need to shift from general software training towards standardised performance measurement, ethical AI governance, and competency frameworks tailored to specific needs and contexts. These findings offer a strategic roadmap for preparing educators to lead meaningful, effective and responsible digital learning amidst the evolution of AI-driven education.

Keywords: *educators' digital competences; educational technology; TPACK; DigCompEdu; generative artificial intelligence; pedagogical integration; data privacy; digital ethics*

INTRODUCTION

Over the last three decades, digital technology in education has evolved from an auxiliary resource into a foundational infrastructure. The term computer transformed from human mathematicians executing complex calculations ((as seen in Hidden Figures; Shetterly, 2016) to powerful machines driving global workforce demands. As computing became essential for the future of work, educational systems rapidly adapted, forcing teachers from all disciplines to quickly master and teach technologies that were constantly shifting under their feet.

However, defining what it means for an educator to be “digitally competent” quickly proved to be a moving target, as basic technical proficiency was no longer enough to meet the demands of modern classrooms. Early efforts to build digital

competency relied on basic guidelines and brief training sessions focused primarily on software operation (Faloon, 2020). While this introduced student-centered, independent learning models, it created a new pedagogical dilemma: how to maintain academic rigor and deep subject-matter content while integrating constantly changing digital tools.

To bridge this gap between mere technical operation and effective teaching, researchers began developing comprehensive theoretical frameworks, known as the Technological Pedagogical Content Knowledge (TPACK) model, to redefine competency as the intersection of technology, pedagogy, and subject expertise (Koehler et al., 2013). Under these frameworks, digital competency was no longer viewed as an isolated technical skill, but as a holistic ability to blend content with appropriate digital media. However, as educational technology transitioned from static tools to data-driven platforms and generative AI, these initial models faced new pressures, forcing the definition of teacher competency to expand once more into ethical governance, data privacy, and digital resilience.

In order to establish a thorough view of how digital competence among teachers has been defined and constructed over time, looking back across three decades offers vital context for understanding our current educational landscape. By tracing these historical shifts, researchers and policymakers can avoid repeating past training missteps and better anticipate how educators adapt to technological disruption. Therefore, this narrative review examines the 30-year trajectory of teacher digital competency (1996–2026). Specifically, this paper addresses two guiding questions:

Method

This study uses a narrative literature review to examine the evolution of digital competence and digital literacy in enhancing teaching competence over the past three decades. A total of 20 peer-reviewed articles published between 1996 and 2026 were selected to capture the conceptual development of the field, beginning with the emergence of digital literacy as a key educational construct and extending to contemporary frameworks for teacher digital competence. The selected studies were chosen based on their relevance to teacher digital competence, digital literacy, educational technology integration, and competency frameworks in educational settings.

Rather than applying a statistical synthesis, the review adopted an interpretive approach to identify recurring themes, compare conceptual perspectives, and trace shifts in scholarly understanding over time. The literature was synthesized into four thematic facets: (1) conceptual and theoretical frameworks, (2) dimensions of teacher digital competence and digital literacy, (3) barriers to adoption and implementation, and (4) emerging trends and unresolved research gaps. This approach enabled a

comprehensive understanding of how the discourse has evolved and highlighted directions for future research and practice.

Result and Discussion

Based on the categorization made before, the general definition of digital competence is shown in Table 1.

Table 1. The shift of definition along with representative framework

Year of Shift	How competency was defined	Representative frameworks
1990s-2000s	Technical operation and software use	UNESCO ICT guidance, national ICT standards
2000s-2010s	Digital literacy as skills, knowledge, attitudes, critical use	Digital literacy traditions, DigComp
2010s-early 2020s	Teaching-specific integration of technology, pedagogy, and content	TPACK, DigCompEdu, INTEF, ISTE
2020s-on going	Security, ethics, institutional capacity, and AI-ready practice	security indicators, AI-TPACK, AI literacy frameworks

In order to provide a structured overview of the literature, this review is organized into four facets: frameworks, competency dimensions, adoption barriers, and unresolved gaps. Among the existing frameworks, TPACK and DigCompEdu remain the most widely adopted. However, recent studies increasingly argue that higher education requires broader, context-specific, and ethically grounded models (Zhang et al., 2026; Gonzales-Medina et al., 2025; Faloon et al., 2020).

Framework

TPACK is the most widely used model for studying teacher digital competence, especially for explaining how technological, pedagogical, and content knowledge must be integrated rather than treated separately (Zhang et al., 2026; Li et al., 2022). DigCompEdu is the other major anchor, especially in higher education, because it specifies six educator domains: professional engagement, digital resources, teaching

and learning, assessment, learner empowerment, and facilitating students' digital competence (Chifla-Villón et al., 2025; Kiryakova & Kozhuharova, 2024; Gonzales-Medina et al., 2025).

Recent studies increasingly combine frameworks rather than choosing one. Reviews describe TPACK as a macro-level lens for strategic technology integration and DigComp or DigCompEdu as micro-level operational domains, with integration proposed as a way to offset the limitations of single-model approaches (Zhang et al., 2026; Miguel-Revilla et al. 2019). Higher education also shows movement toward adapted models, including HeDiCom for university teaching, XR-specific extensions of DigCompEdu, and datasets that cross-reference DKAP with TPACK and DigComp frameworks. TPACK remains the main integration model across studies, while DigCompEdu is the main multidimensional assessment framework in higher education. However, newer models are increasingly context-specific for universities, XR, or subject areas (Zhang et al., 2026; Rutten & Brouwer-Truijen, 2025; Nguyen et al., 2026; Seifert, & Lindmeier, 2024; Althubayani, 2024; Su, 2023).

Competency Dimensions

The field no longer treats digital competence as simple ICT skill. Most papers describe it as a multidimensional construct spanning technical ability, pedagogical design, professional engagement, assessment, learner empowerment, and support for students' own digital competence (Chifla-Villón, 2025; Esteve-Mon et al., 2020; Anggraini et al., 2025). Several studies also add explicit ethical and civic dimensions, including digital citizenship, cybersafety, data management, online judgment, and responsible participation in digitally mediated environments (Faloon et al., 2020; Zhang et al., 2026; Çebi et al., 2022).

A consistent pattern is that teachers often report stronger technical skills than pedagogical application. Reviews and assessments find uneven performance across dimensions, with recurring weaknesses in digital content creation, problem-solving, assessment, and contextual pedagogical integration (Zhang et al., 2026; Garzón Artacho, 2020; Fernández-Batanero et al., 2020; Seifert & Lindmeier, 2024). Performance-based work in mathematics also supports a two-part structure separating technical-mathematical from pedagogical competence, and self-reports do not always align cleanly with measured performance (Seifert & Lindmeier, 2024).

Former models separate technical, pedagogical, and content-linked knowledge (Seifert & Lindmeier, 2024; Li et al., 2022). Instead, newer models add ethical and citizenship dimensions (Faloon et al., 2020; Kiryakova & Kozhuharova, 2024). While weakest areas often include content creation and pedagogical integration (Zhang et al., 2026; Garzón Artacho, 2020).

Adoption Barriers

The most common barrier is not lack of basic digital familiarity but difficulty translating it into effective pedagogy. University teacher educators report using digital tools without primarily pedagogical purposes and needing extensive support to create digital teaching with clear pedagogical value (Amhag et al. 2019). Reviews similarly find adequate technical competence but lower pedagogical use, especially for teaching development and contextual integration (Esteve-Mon et al., 2020; Anggraini et al., 2025).

Furthermore, barriers also include infrastructure, training inequality, workload, and institutional support deficits. Studies cite limited access to tools, uneven infrastructure between urban and remote areas, administrative burdens, and lack of ongoing policy-backed professional development (Anggraini et al., 2025; Althubyani, 2024; Oktaviani & Utami, 2024). The main barrier is weak pedagogical translation of existing digital skills. This issue is then enhanced by infrastructure and policy gaps that limit adoption, especially in underserved settings. Whereas, training works best when it is ongoing and context-adapted (Amhag et al. 2019; Esteve-Mon et al., 2020; Anggraini et al., 2025; Oktaviani & Utami, 2024).

Unresolved Gaps According to Evidence-based Research Coverage

Based on the review, research gaps around teacher digital competence themes are shown in Table 2 below.

Table 2. Research Coverage

Sub-Topic	Framework consensus	Assessment quality	Intervention evidence	Ethics and safety	Higher-ed specificity
TPACK-based models	9	6	5	1	4
DigComp Edu studies	8	7	4	3	5
Subject-specific competence	3	3	2	GAP	2

Sub-Topic	Framework consensus	Assessment quality	Intervention evidence	Ethics and safety	Higher-ed specificity
Emerging tech and AI/XR	2	1	2	1	2
Organizational conditions	2	1	1	1	3

The sharpest gap is valid assessment beyond self-report. Reviews note less rigorous designs and limited representativeness, while performance-based work explicitly argues that standardized, valid, proximal assessments are still lacking and that self-assessment aligns only mixed with measured competence (Zhang et al., 2026; Seifert & Lindmeier, 2024).

A second gap is context specificity. General frameworks are widely used, but XR teaching required an explicit DigCompEdu extension, and subject-specific mathematics assessment had to operationalize separate technical-mathematical and pedagogical dimensions (Rutten & Brouwer-Truijen, 2025; Seifert, & Lindmeier, 2024). The field also remains thin on developing-country contexts and institution-level conditions, with several papers noting overconcentration in developed settings and insufficient attention to infrastructure, policy, and organizational support (Anggraini et al., 2025).

Throughout the literature, teacher digital competency is now defined as a multidimensional professional capability. On the other hand, the evidence base still needs stronger measurement, more intervention studies, and better coverage of ethics, emerging technologies, and higher-education-specific contexts. Such efforts will provide a stronger foundation for preparing educators to meet the evolving demands of digital teaching and learning in higher education.

Across higher education, the term “digital competence” and “digital literacy” were often used interchangeably, although reviews note that definitions still vary between policy-led, research-led, technical, and social-practice interpretations Spante et al., 2018; Zhang et al., 2026). In the earliest phase, competency was framed mainly as ICT skills: using computers, software, and digital tools effectively for work and teaching, with UNESCO’s 2008 ICT guidance marking an important codification point (Fernández-Batanero et al., 2020). This skills-first view is now widely treated as insufficient, because basic ICT use does not by itself produce competent teaching practice. By the 2000s and 2010s, the definition broadened from tool handling to digital literacy and multidimensional competence, including knowledge, attitudes, creativity,

communication, collaboration, critical use, and problem-solving (Esteve-Mon et al., 2020; Zhang et al., 2026)

Teacher digital competency in higher education has evolved from basic ICT operation to pedagogical integration, broader digital literacy, and now early AI-readiness and governance concerns. Higher-education literature shows three linked shifts: technical ICT skills, pedagogical-digital competence, and newer attention to security, ethics, institutional capacity, and AI literacy (Lan et al., 2024; Spante et al., 2018; Biagini, 2025). Teacher digital competency in higher education has progressed through three main phases over the last 30 years. The arc moves from tool use, to integrated teaching competence, to system-level and AI-related readiness. The most recent phase is still emerging and is less standardized than DigCompEdu- or TPACK-era work.

Higher-education frameworks increasingly distinguished generic digital ability from teaching-specific competence. Krumsvik's levels, TPACK, and later DigCompEdu progressively reframed digital competence as the capacity to integrate technology with pedagogy, content, learner empowerment, assessment, and professional development, moving beyond a narrow focus on access and operational skills (Esteve-Mon et al., 2020; Wohlfart & Wagner, 2022; Zhao et al., 2021). Collectively, these frameworks illustrate the field's shift from technology-centered perspectives toward pedagogically grounded models of teacher digital competence.

The newest shift extends digital competence beyond pedagogy to responsible digital governance. Reviews now include privacy, data protection, ethical technology use, security, digital resources, and organizational leadership as core or adjacent dimensions, showing that competence is no longer treated as an individual teacher trait alone (Torres-Hernández & Gallego-Arrufat, 2022; Heine et al., 2022; Pettersson, 2018). AI readiness in higher education is emerging from this broader base rather than replacing it. Recent reviews argue that AI literacy should emphasize data and algorithm understanding, problem-solving, critical and ethical integration, and AI-based decision awareness, shifting the question from whether teachers can use digital tools to whether they are ready for AI-enhanced pedagogy and governance (Chee et al., 2024; Zhang et al., 2026; Biagini, 2025).

Simultaneously, preserving security and privacy are now explicit competency areas, not hidden subskills (Torres-Hernández & Gallego-Arrufat, 2022). Competence increasingly includes institutional and leadership conditions for digital transformation (Pettersson, 2018; Timotheou et al., 2022). AI frameworks address ethical, strategic, and responsible integration, not just tool use (Chee et al., 2024; Biagini, 2025). Over 30 years, the higher-education definition of teacher digital competency has widened from basic ICT proficiency to a multidimensional professional competence for teaching, learner empowerment, and continuous development. The newest frontier is AI governance readiness, but the literature still shows weaker agreement here than for digital literacy, TPACK, or DigCompEdu.

Conclusion

Over the past three decades, teacher digital competency has shifted from basic software operation to a complex, multidimensional capability. While early models focused primarily on technical skills and tool usage, the emergence of frameworks like TPACK and DigCompEdu successfully anchored digital competency within pedagogical and content design. Today, as educational technology moves into generative AI and data-driven platforms, competency has expanded once again to include ethical governance, privacy, and system-level readiness. Ultimately, the literature demonstrates that being a digitally competent educator is no longer about tool mastery, but about adaptive, pedagogically grounded integration.

Moving forward, this historical trajectory highlights several critical considerations for future policy and educator training. First, professional development must address the persistent gap between teachers' technical fluency and their ability to translate those skills into rigorous pedagogy. Second, institutions must move beyond self-reported assessments by developing standardized, performance-based measures of digital competency. Finally, as AI becomes ubiquitous, frameworks must explicitly integrate ethics, data protection, and subject-specific needs rather than relying on one-size-fits-all models. Addressing these gaps ensures that teachers are not merely adopting new technologies, but are equipped to lead meaningful and ethical digital learning.

Limitation

This review is limited by its reliance on a narrative synthesis of 20 selected studies, which may not capture the full breadth of research on digital competence and digital literacy. The findings are based on an interpretive analysis rather than a systematic review or meta-analysis, making them susceptible to selection and interpretation bias. Nevertheless, the review provides a broad overview of the evolution of the field and identifies key themes that can inform future research.

Recommendation

Future research should replace generic self-assessment surveys with validated, proximal performance measures to evaluate actual teaching competency. Scholars must also prioritize empirical investigations into emerging AI-TPACK models, ethical governance, and context-specific framework adaptations, particularly within higher education and underserved regions. Such targeted efforts will ensure that digital literacy frameworks evolve from abstract guidelines into actionable, evidence-based practices for modern educators.

References

- Althubyani, A. R. (2024). Digital Competence of Teachers and the Factors Affecting Their Competence Level: A Nationwide Mixed-Methods Study. *Sustainability*. <https://doi.org/10.3390/su16072796>
- Amhag, L., Hellström, L., & Stigmar, M. (2019). Teacher Educators' Use of Digital Tools and Needs for Digital Competence in Higher Education. *Journal of Digital Learning in Teacher Education*, 35, 203 - 220. <https://doi.org/10.1080/21532974.2019.1646169>
- Anggraini, F. N., Maksum, M. N. R., Azani, M. Z., Azzahrowaini, L., Jihad, F. A., & Fauzan, S. (2025). Teacher Readiness and Strategy in the Implementation of Digital Pedagogy in 21st Century Education. *ICEETE Conference Series*. <https://doi.org/10.36728/iceete.v3i1.240>
- Çebi, A., Özdemir, T. B., Reisoglu, I., & Çolak, C. (2022). From digital competences to technology integration: Re-formation of pre-service teachers' knowledge and understanding. *International Journal of Educational Research*. <https://doi.org/10.1016/j.ijer.2022.101965>
- Chifla-Villón, M. R., Chifla-Villón, M. P., Suárez-Guartamber, E. M., & Guevara-Viejó, F. (2025). Multidimensional assessment and validation of digital competencies in university teacher education: a confirmatory factor analysis. *Frontiers in Education*. <https://doi.org/10.3389/feduc.2025.1597095>
- Esteve-Mon, F. M., Llopis-Nebot, M. Á., & Adell-Segura, J. (2020). Digital Teaching Competence of University Teachers: A Systematic Review of the Literature. *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje*, 15, 399-406. <https://doi.org/10.1109/rita.2020.3033225>
- Falloon, G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational Technology Research and Development*, 68, 2449 - 2472.
- Fernández-Batanero, J., Román-Graván, P., Montenegro-Rueda, M., López-Meneses, E., & Fernández-Cerero, J. (2021). Digital Teaching Competence in

Higher Education: A Systematic Review. *Education Sciences*.

<https://doi.org/10.3390/educsci11110689>

Garzón Artacho, E., Sola Martínez, T., Martín, J. L. O., Marín Marín, J. M., & Gómez García, G. (2020). Teacher Training in Lifelong Learning—The Importance of Digital Competence in the Encouragement of Teaching Innovation. *Sustainability*. <https://doi.org/10.3390/su12072852>

González-Medina, I., Gavín-Chocano, Ó., Pérez-Navío, E., & Berea, G. A. M. (2025). Trajectories of Digital Teaching Competence: A Multidimensional PLS-SEM Study in University Contexts. *Inf.*, 16, 373.

<https://doi.org/10.3390/info16050373>

Shetterly, M. L. (2016). *Hidden Figures: The American Dream and the untold story of the Black women mathematicians who helped win the space Race*.

[https://en.wikipedia.org/wiki/Hidden_Figures_\(book\)](https://en.wikipedia.org/wiki/Hidden_Figures_(book))

Kiryakova, G., & Kozhuharova, D. (2024). The Digital Competences Necessary for the Successful Pedagogical Practice of Teachers in the Digital Age. *Education Sciences*. <https://doi.org/10.3390/educsci14050507>

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content knowledge (TPACK)? *Journal of education*, 193(3), 13-19.

<https://doi.org/10.1177/002205741319300303>

Li, S., Liu, Y., & Su, Y.-S. (2022). Differential Analysis of Teachers' Technological Pedagogical Content Knowledge (TPACK) Abilities According to Teaching Stages and Educational Levels. *Sustainability*.

<https://doi.org/10.3390/su14127176>

Miguel-Revilla, D., Martínez-Ferreira, J. M., & Sánchez-Agustí, M. (2019).

Assessing the digital competence of educators in social studies: An analysis in initial teacher training using the TPACK-21 model. *Australasian Journal of Educational Technology*, 36, 1-12. <https://doi.org/10.14742/ajet.5281>

- Nguyen, H., Nguyen, H., & Ngo, T.-T.-T. (2026). Survey data on digital competence assessment among pre-service teachers in Vietnam. *Data in Brief*, 65. <https://doi.org/10.1016/j.dib.2026.112465>
- Oktaviani, H., & Utami, D. D. (2024). Development Of Training Programs To Enhance Teachers' Digital Skills With Technological Pedagogical Content Knowledge (TPACK). *Journal of Educational Technology Studies and Applied Research*. <https://doi.org/10.70125/jetsar.v1i2y2024a23>
- Revuelta-Domínguez, F.-I., Guerra-Antequera, J., González-Pérez, A., Pedrera-Rodríguez, M.-I., & González-Fernández, A. (2022). Digital Teaching Competence: A Systematic Review. *Sustainability*. <https://doi.org/10.3390/su14116428>
- Rutten, N., & Brouwer-Truijen, K. (2025). Defining XR-Specific Teacher Competencies: Extending the DigCompEdu Framework for Immersive Education. *Trends in Higher Education*. <https://doi.org/10.3390/higheredu4010011>
- Seifert, H.-U., & Lindmeier, A. (2024). Developing a Performance-Based Assessment to Measure Pre-Service Secondary Teachers' Digital Competence to Use Digital Mathematics Tools. *Journal für Mathematik-Didaktik*, 45. <https://doi.org/10.1007/s13138-024-00251-7>
- Su, Y. (2023). Delving into EFL teachers' digital literacy and professional identity in the pandemic era: Technological Pedagogical Content Knowledge (TPACK) framework. *Heliyon*, 9. <https://doi.org/10.1016/j.heliyon.2023.e16361>
- Zhang, L., Yang, C., & Zheng, Y. (2026). Digital competence for sustainable education of pre-service teachers: a systematic literature review (2014–2024). *Frontiers in Psychology*, 16. <https://doi.org/10.3389/fpsyg.2025.1710983>