https://doi.org/10.15625/2615-8965/22620102

From Frameworks to Trajectories: Toward an Emergent Understanding of Teacher Digital Competence

Dao Xuan Phuong Trang[1], Nguyen Thi Xuan Lan[2]✉, Vo Doan Tho[3]

[1] trangdxp.23at@ou.edu.vn
Graduate School, Ho Chi Minh City Open University (HCMCOU),
97 Vo Van Tan street, Xuan Hoa ward,
Ho Chi Minh City,
(Vietnam)
trangdxp@hcmue.edu.vn
English Department, Ho Chi Minh City University of Education (HCMUE),
(Vietnam)

[2] lan.ntx@ou.edu.vn
Centre for Educational Research and Innovation, Ho Chi Minh City Open University (HCMCOU),
97 Vo Van Tan street, Xuan Hoa ward,
Ho Chi Minh City,
(Vietnam)

[3] doantho@ueh.edu.vn
University of Economics Ho Chi Minh City (UEH),
59C Nguyen Dinh Chieu street, Xuan Hoa ward,
Ho Chi Minh City,
(Vietnam)

✉ Corresponding author

ABSTRACT: *Teacher digital competence (TDC) has become a central concern in education, often framed through influential models which generally provide structured ways to define competence. This study adopts a qualitative, theory-informed conceptual analysis of three influential frameworks, including TPACK, DigCompEdu, and SAMR, selected for their sustained influence on research, policy, and professional development. Drawing on qualitative content analysis, key conceptual and policy texts associated with these frameworks were examined through Bronfenbrenner's Ecological Systems Theory and interpreted through a postdigital perspective. Findings indicate that selected models prioritize knowledge integration, staged progression, or standardized descriptors, while underrepresenting the contextual, relational, and temporal dimensions of teachers' practice. These limitations are particularly visible in contexts with uneven conditions, such as Vietnam, where institutional constraints, resource disparities, and policy demands shape how competence is enacted. Based on recurring patterns across the three frameworks, the study proposes an ecological-postdigital trajectory as an alternative conceptualization of TDC. From this perspective, competence is not a fixed set of domains or levels, but an evolving process shaped by interactions between teacher agency and multi-layered systems over time. This reframing repositions existing frameworks as heuristic tools rather than comprehensive representations of competence. The study contributes a theoretically grounded perspective that shifts attention from static models to dynamic processes, with implications for research, professional development, and policy design.*

KEYWORDS: **Teacher digital competence, professional development, TPACK, DigCompEdu, SAMR.**

Received 12/11/2025 → Revised manuscript received 14/3/2026 → Published 16/9/2026.

1. Introduction

Technology is now deeply embedded in social, cultural, and economic life. It reshapes how people work, communicate, and learn. In education, this shift has elevated digital competence from a supplementary skill to a core requirement for both learners and teachers. As a result, teacher digital competence (TDC) has become a global policy priority. It is reflected in professional standards, curriculum reforms, and large-scale professional development (PD) initiatives designed to support digitally mediated teaching (Garzón-Artacho et al., 2021).

In response, research and policy have relied heavily on frameworks to define, structure, and assess TDC. Widely used models such as TPACK, DigCompEdu, and SAMR organize competence into domains, descriptors, or developmental stages (Mishra & Koehler, 2006; Redecker, 2017; Puentedura, 2006). These frameworks have made important contributions. They provide a shared vocabulary, enable cross-context comparison, and offer practical guidance for teacher education and PD. However, their key strength—conceptual clarity through categorization—also creates limitations. By presenting competence as discrete components or linear progressions, these models risk reducing TDC to a measurable product. This,

in turn, tends to obscure the dynamic, situated, and relational processes through which teachers develop competence in practice (Brianza et al., 2022; Hamilton et al., 2016; Tóth et al., 2024).

This tension is particularly visible in contexts where educational conditions are uneven and rapidly changing. In Vietnam, recent reforms have positioned TDC as a key professional requirement. This has led to the widespread adoption of framework-informed PD initiatives (Pham et al., 2018; Nguyen & Tran, 2018). While these efforts show strong institutional commitment, they also reveal structural limitations. PD programs often focus on tool use, instructional design, and assessment integration. They pay less attention to the contextual and relational dimensions of teaching. In addition, standardized training formats tend to assume similar conditions across settings. This overlooks disparities in infrastructure, institutional support, and classroom realities. As a result, teachers' opportunities to develop and enact TDC remain uneven, particularly between urban and rural contexts (Nguyen, 2018). Although this example is not an empirical evaluation, it illustrates how assumptions embedded in dominant frameworks can constrain PD in practice.

These limitations point to a broader conceptual issue. Frameworks provide necessary structure, but their dominance might narrow how TDC is understood, developed, and evaluated. In particular, they tend to privilege stability over change, standardization over context, and measurement over process. Such orientations are, without doubt, increasingly inadequate in educational environments marked by rapid technological change, evolving pedagogical expectations, and diverse teaching conditions. Accordingly, what is needed is not simply the refinement of existing frameworks, but a reconceptualization of TDC that foregrounds its developmental, situated, and relational nature.

To address this need, this study adopts a theory-informed conceptual approach to examine three influential frameworks—TPACK, DigCompEdu, and SAMR. Rather than evaluating their effectiveness, the study treats these models as analytical entry points for uncovering underlying assumptions about competence, development, and professional learning. Guided by Bronfenbrenner's Ecological Systems Theory (EST) and informed by postdigital perspectives, the analysis explores how these frameworks represent—or overlook—the multi-layered and context-dependent processes through which teachers engage with digital technologies.

The study is guided by the following research questions:

1. How do frameworks such as TPACK, DigCompEdu, and SAMR shape current understandings of TDC and its development?

2. What limitations arise when TDC is conceptualized through component-based or stage-based models, particularly in contexts with uneven conditions such as Vietnam?

3. How can TDC be reconceptualized as a developmental trajectory that is situated, relational, and emergent over time?

In response to these questions, the paper aims to advance a reconceptualization of TDC as an ecological and postdigital trajectory. This perspective conceptualizes competence not as a fixed set of domains or levels, but as an evolving process shaped through the interaction between teacher agency and the multiple systems—classroom, institutional, and societal—in which practice is embedded. This shift enables the study to contribute a theoretically grounded alternative for understanding and supporting teachers' digital competence in complex and changing educational environments.

2. Literature review

2.1. Technology, pedagogy, and postdigital educational change

The integration of technology in education has not followed a linear path of continuous improvement. Instead, it shows a cyclical pattern of adoption, critique, and reconfiguration. From early mechanical tools and computer-assisted language learning (CALL) to networked platforms and, more recently, artificial intelligence, each wave of innovation has interacted with prevailing pedagogical paradigms. These interactions reshape assumptions about teaching and learning (Roby, 2004; Butler-Pascoe, 2011; Son, 2018;

Urbaite, 2024). This perspective suggests that technology does not simply enhance existing practices. It reconfigures the conditions under which teaching and learning occur.

This co-evolution highlights the relational and contextual nature of educational change. The effectiveness of digital practices cannot be understood in isolation from institutional conditions, disciplinary traditions, and broader sociocultural expectations. Empirical studies show that teachers' digital competence is shaped by the interaction of these factors, rather than by technical skills alone (Cattaneo et al., 2022; Fernández-Batanero et al., 2022

A postdigital perspective offers a useful lens for interpreting these dynamics. It does not treat the digital as a separate or dominant domain. Instead, it emphasizes the entanglement of technological, pedagogical, and social dimensions of practice (Örtegren, 2023). In this view, technology is neither an external tool nor a deterministic force. It is part of a complex assemblage through which teaching is enacted. As a result, what counts as effective digital competence is contingent, negotiated, and continuously redefined. This challenges models that treat competence as stable, transferable, or universally applicable.

2.2. TDC and the limits of framework-based models

The concept of TDC has evolved alongside changing views of technology in education. Early approaches equated competence with technical proficiency, focusing on skills such as communication, information management, and problem-solving (Glister, 1997; Fraile et al., 2018). While these skills remain important, they do not capture the pedagogical complexity of technology integration.

Later frameworks expanded this view. The TPACK model conceptualizes competence as the integration of technological, pedagogical, and content knowledge. Policy-oriented frameworks such as UNESCO's ICT-CFT and DigCompEdu define competence through structured domains and descriptors (Mishra & Koehler, 2006; UNESCO, 2011; Redecker, 2017). These approaches have shaped both research and professional development by providing shared terminology and operationalizable constructs.

Despite their influence, framework-based models have been widely critiqued. A key concern is their tendency to fragment competence into discrete domains or to represent development as linear progression. These representations can obscure the situated and evolving nature of teaching. In practice, decisions about technology use are shaped by context, constraints, and professional judgment, rather than by fixed categories (Brianza et al., 2022). In addition, universal frameworks often struggle to accommodate variation across settings. This makes them difficult to apply meaningfully in diverse or resource-constrained contexts.

These limitations became especially visible during the COVID-19 pandemic. Teachers were required to rapidly adapt to online and hybrid teaching. This shift exposed the limits of viewing competence as a stable set of skills. Instead, it highlighted the importance of institutional support, peer collaboration, and access to resources. In this sense, TDC is historically contingent and responsive to broader disruptions (Örtegren, 2023).

In response, recent research has moved toward more holistic perspectives. The concept of Professional Digital Competence (PDC), for example, extends beyond technical and pedagogical knowledge to include professional practice and transformative agency (Gudmundsdottir & Hatlevik, 2018, 2020). This perspective emphasizes teachers' capacity to interpret, adapt, and reshape digital practices in response to changing conditions.

Taken together, conceptualizing TDC as a fixed set of skills or descriptors is becoming inadequate for capturing its dynamic and context-dependent nature. A shift is therefore needed toward understanding TDC as emerging from interactions between teachers and the multiple systems in which they operate.

2.3. Theoretical framework: An ecological-postdigital lens on TDC

This study adopts an ecological–postdigital perspective on TDC. EST serves as the primary analytical lens, while postdigital thinking

provides an epistemological orientation. Together, these perspectives support a view of TDC as situated, relational, and evolving.

2.3.1. Ecological systems theory as analytical lens

Bronfenbrenner's Ecological Systems Theory conceptualizes development as emerging from interactions between individuals and the multiple, nested systems in which they are embedded (Bronfenbrenner, 1979, 1986). Rather than focusing only on individual attributes or isolated contexts, EST emphasizes the interdependence of environmental layers and their cumulative influence over time.

When applied to the teacher's context, the theory distinguishes five interconnected systems. The microsystem refers to teachers' immediate environments, including classrooms, students, colleagues, and daily practices. The mesosystem captures interactions between these environments, such as relationships between schools and PD providers. The exosystem includes institutional structures that indirectly shape practice, such as policies, infrastructure, and organizational arrangements. The macrosystem reflects broader cultural and policy contexts that shape expectations about education and technology. Finally, the chronosystem introduces a temporal dimension, highlighting how development unfolds over time in response to changing conditions, such as technological innovation or educational reform.

In the context of TDC, EST provides a structured way to examine how competence is shaped across these levels. It shifts the focus from competence as an individual attribute to competence as the outcome of interactions between teachers and their environments. This makes EST particularly useful for analysing the limits of framework-based models, which often emphasize individual skills while underrepresenting systemic influences.

2.3.2. Postdigital perspective as epistemological orientation

While EST offers a structural lens, a postdigital perspective helps explain the nature of digital competence. It challenges the idea that the "digital" is a separate or dominant domain. Instead, it highlights the inseparability of technological, social, and pedagogical dimensions of practice.

From this perspective, technology is not an external tool applied to teaching. It is part of an entangled system in which practices, meanings, and relationships are continuously co-constructed (Olofsson et al., 2021; Almas et al., 2021). As a result, competence cannot be reduced to a stable or transferable set of skills. It emerges through situated engagement with evolving technological and social conditions.

This perspective strengthens the ecological view by emphasizing the fluid and contingent nature of practice across all system levels. It also challenges dominant frameworks that present competence as fixed, measurable, and decontextualized.

2.3.3. Integrating ecological and postdigital perspectives

Together, EST and postdigital perspectives provide a coherent framework for this study. Different from existing theories such as sociocultural perspectives which conceptualize competence as learning through participation in various social contexts (Lave & Wenger, 1991), EST offers the structural dimensions for analysing how competence is distributed across systems. As the interactions between contextual layers are complicated, they should be viewed as conditions contributing to the shaping of TDC rather than the environment of participative learning. In addition, postdigital thinking explains why competence is inherently dynamic, relational, and context-dependent. This is the broader view compared to Gudmundsdottir and Hatlevik's Professional Digital Competence (PDC) (2018, 2020) which emphasizes teachers' professional judgment, ethical responsibility, and transformative agency in digital environments. The view is particularly significant in the technology-driven era when technological, pedagogical, and social practices are increasingly inseparable. The relationship between human and technology is no longer simple as users and tools. Though humans are

still the centre, technology, especially artificial intelligence (AI), now can perform the role of a cognitive partner who co-plan, co-think, co-design, and co-learn with teachers (Raisch & Krakowski, 2021), Therefore, the integration of ecological and postdigital perspectives does not seek to replace PDC or sociocultural approaches, but manifests concerns with agency, context, and technological entanglement into a developmental view of competence as a situated, relational, and evolving trajectory. This allows the study to move beyond evaluating frameworks in terms of completeness or accuracy. Instead, it examines how frameworks construct particular versions of competence. Specifically, it analyses how they emphasize certain ecological levels while neglecting others, and how they stabilize what is, in practice, a fluid and evolving process.

3. Methodology

This study adopts a qualitative, theory-informed conceptual analysis to examine how dominant frameworks shape understandings of TDC. Rather than generating empirical data, it analyses influential conceptual and policy texts as sites where assumptions about competence, development, and professional learning are constructed and stabilized.

The analysis is guided by EST as the primary analytical lens. EST provides a structured framework for examining how TDC is represented across interacting levels of influence, from classroom practice to institutional and policy contexts. A postdigital perspective complements this lens by shaping how these representations are interpreted. It highlights the entangled and evolving nature of technological, pedagogical, and social practices. In this study, postdigital thinking functions as an epistemological orientation rather than a separate analytical framework.

Methodologically, the study draws on qualitative content analysis (Kuckartz, 2014). It combines deductive and inductive strategies to examine how TDC is defined, structured, and operationalized within selected frameworks. Deductive categories, derived from the research questions, guide the initial coding. Inductive analysis then identifies patterns and distinctions across cases. This approach supports a systematic yet interpretive analysis.

Given the ecological and postdigital premise that TDC is shaped by interconnected influences, the scope of analysis must be clearly defined. To achieve this, the study uses Barad's (2007) concept of agential cuts. This concept allows the analysis to set boundaries—specifically by focusing on professional development contexts—while acknowledging that these boundaries are analytically constructed.

Taken together, this design establishes a clear division of roles: EST structures the analysis, postdigital thinking informs interpretation, qualitative content analysis provides methodological procedures, and agential cuts define scope. This integrated approach supports a coherent and theoretically grounded examination of TDC as an ecological and evolving construct.

3.1. Framework selection

The selection followed three criteria. First, the framework needed to focus explicitly on teacher digital competence or technology integration in educational contexts. Second, it needed to demonstrate sustained influence in research, policy, or professional development, as evidenced by frequent citation and continued use in recent literature. Through systematic reviews, policy documents, and empirical studies indexed in databases such as SCOPUS and Web of Science, we selected three frameworks: TPACK, DigCompEdu, and SAMR. Then, we proceeded to consider the third criterion to confirm our selection. Here, each framework needed to represent a distinct conceptual approach to competence, and the three selected ones satisfied this criterion. To be specific, TPACK, DigCompEdu, and SAMR respectively represent knowledge integration, competence descriptors, and staged technology integration.

3.2. Data corpus

The analysis draws on a purposively defined corpus of key texts associated with each framework. These include foundational

publications, conceptual clarifications, and influential critiques that shape how each framework is interpreted and applied.

For TPACK, the corpus includes the original formulation (Mishra & Koehler, 2006) and widely cited conceptual and empirical studies (e.g., Koehler et al., 2013; Voogt et al., 2013; Graham, 2011; Archambault & Barnett, 2010). For SAMR, it includes Puentedura's original model (2006) and key critiques (e.g., Hamilton et al., 2016; Blundell et al., 2022; Brianza et al., 2022; Tóth et al., 2024). For DigCompEdu, the primary source is the European Commission report (Redecker, 2017), supplemented by studies on its theoretical grounding and application (e.g., Caena & Redecker, 2019; Instefjord & Munthe, 2021; Reisoğlu & Çebi, 2022).

In total, the corpus includes 14 documents selected for their conceptual influence and representativeness. Consistent with the conceptual nature of the study, the aim was not exhaustive literature coverage but analytical depth. Documents were selected because they played a significant role in defining, refining, critiquing, or operationalizing each framework, thereby providing a theoretically meaningful corpus for comparative analysis. Table 1 summarizes the selected documents and their rationale.

3.3. Analytical procedure

The analysis followed a structured and iterative process combining deductive and inductive coding. First, all texts were read multiple times to identify segments that addressed three analytical dimensions: (1) conceptualization of competence, (2) models of development, and (3) assumptions about professional development. These categories were derived from the research questions. For analytical consistency, conceptualization of competence refers to how each framework defines the nature and components of teacher

Table 1. Documents included in the conceptual analysis of TDC frameworks

Framework	Type of source	Citation	Rationale for inclusion
TPACK	Foundational framework	(Mishra & Koehler, 2006)	Original formulation of TPACK; establishes core constructs and relationships between technology, pedagogy, and content knowledge.
TPACK	Conceptual clarification	(Koehler et al., 2013)	Provides clarification and refinement of TPACK constructs; widely cited in subsequent literature.
TPACK	Theoretical critique	(Graham, 2011)	Offers critical theoretical analysis of TPACK; frequently cited in discussions of its conceptual limitations.
TPACK	Literature review	(Voogt et al., 2013)	Synthesizes empirical and conceptual developments of TPACK; demonstrates its widespread adoption.
TPACK	Empirical/ conceptual study	(Archambault & Barnett, 2010)	Examines operationalization of TPACK in practice; highlights challenges in defining and measuring constructs.
DigCompEdu	Foundational framework	(Redecker, 2017)	Official policy framework defining teacher digital competence across domains and proficiency levels.
DigCompEdu	Conceptual/ policy grounding	(Caena & Redecker, 2019)	Explains theoretical and policy foundations of DigCompEdu; outlines its development and validation logic.

Framework	Type of source	Citation	Rationale for inclusion
DigCompEdu	Empirical critique	(Reisoğlu & Çebi, 2022)	Identifies inconsistencies in framework implementation and interpretation in empirical studies.
DigCompEdu	Empirical/contextual study	(Instefjord & Munthe, 2021)	Highlights the importance of contextual and institutional factors in shaping teacher competence.
SAMR	Original model	(Puentedura, 2006)	Introduces SAMR model; widely used in practice for conceptualizing technology integration.
SAMR	Theoretical critique	(Hamilton et al., 2016)	Provides critical evaluation of SAMR; questions its linearity and conceptual clarity.
SAMR	Empirical critique	(Blundell et al., 2022)	Examines contextual variability and ambiguity in applying SAMR levels in practice.
SAMR	Contextual/ theoretical extension	(Brianza et al., 2022)	Highlights limitations of assuming higher SAMR levels are universally desirable.
SAMR	Contextual/ theoretical extension	(Tóth et al., 2024)	Discusses contextual constraints and variability in technology integration practices.

digital competence. Models of development refer to assumptions about how competence grows, changes, or progresses over time. Assumptions about professional development refer to implicit or explicit views regarding how teachers should be supported in developing competence and what conditions are considered important for that development.

Second, coding was conducted at the level of meaning units (sentences or short passages) to ensure consistency across texts.

Third, coded segments were examined inductively to identify recurring patterns and distinctions. These were grouped into sub-themes (e.g., linear progression, knowledge integration, contextual omission), enabling detailed comparison across frameworks.

Fourth, findings were synthesized into analytical profiles for each framework. These profiles captured underlying assumptions, internal logic, and areas of emphasis or omission. A comparative matrix was then used to identify patterns of convergence and divergence.

Finally, findings were interpreted through the lens of EST. Themes were mapped onto ecological levels (micro-, meso-, exo-, macro-, and chronosystem) to examine how each framework represents—or overlooks—different dimensions of teacher development. This enabled a theoretically grounded critique of how TDC is constructed in dominant models.

3.4. Analytical scope and reflexivity

Given the ecological and postdigital premise of this study, it is necessary to delimit the scope of analysis. Following Barad's (2007) concept of agential cuts, the study focuses on TDC as constructed within PD contexts. This boundary provides analytical clarity while acknowledging that other dimensions—such as personal or informal learning—remain relevant but are not examined here.

As an interpretive study, the analysis is shaped by the researchers' theoretical positioning. However, to strengthen analytical consistency, interpretations were continuously compared across frameworks throughout the analysis. Emerging themes were revisited against the original texts to ensure that conclusions remained grounded in the source material rather than imposed by the theoretical lens. This iterative process supported coherence between coding, comparison, and interpretation. Meanwhile, the ecological–postdigital lens foregrounds context,

relationality, and temporality, influencing how frameworks are interpreted. Rather than claiming objectivity in a positivist sense, the study aims for analytical transparency and coherence. This is achieved through explicit coding procedures, systematic comparison, and clear articulation of theoretical assumptions.

While the study does not claim empirical generalizability, it offers theoretical transferability. The identified patterns and limitations may be relevant to other contexts where similar frameworks are applied. In this way, the study contributes to ongoing discussions on how TDC is conceptualized and supported in diverse educational settings.

4. Results

4.1. SAMR model

Several frameworks have been proposed to guide the development of TDC. One of the most influential is the SAMR (Substitution, Augmentation, Modification, Redefinition) model (Puentedura, 2006), which offers a staged view of technology integration (see Fig. 1).

4.1.1. Conceptualization of competence

SAMR conceptualizes teacher digital competence (TDC) as levels of technology use, ranging from substitution to redefinition. Competence is thus defined as the ability to move toward more transformative uses of technology, with "redefinition" positioned as the highest form of practice.

This hierarchical structure is clear and accessible. However, it introduces ambiguity. Studies show that categorizing practices within SAMR is often inconsistent, as the same activity may be interpreted differently across contexts (Blundell et al., 2022). What counts as "redefinition" in one setting may be "augmentation" in another, especially as technologies become normalized.

From an ecological perspective, this suggests that competence cannot be reduced to fixed levels. It is shaped by contextual factors such as tool familiarity, student readiness, and institutional expectations—factors largely absent from the model.

4.1.2. Model of development

SAMR presents development as a linear progression through four stages toward transformation. This progression has been widely critiqued for oversimplification and lack of contextual sensitivity (Hamilton et al., 2016; Blundell et al., 2022). In practice, its use often remains functional, focusing on efficiency rather than pedagogical transformation. It also provides limited guidance on how teachers can move to higher levels.

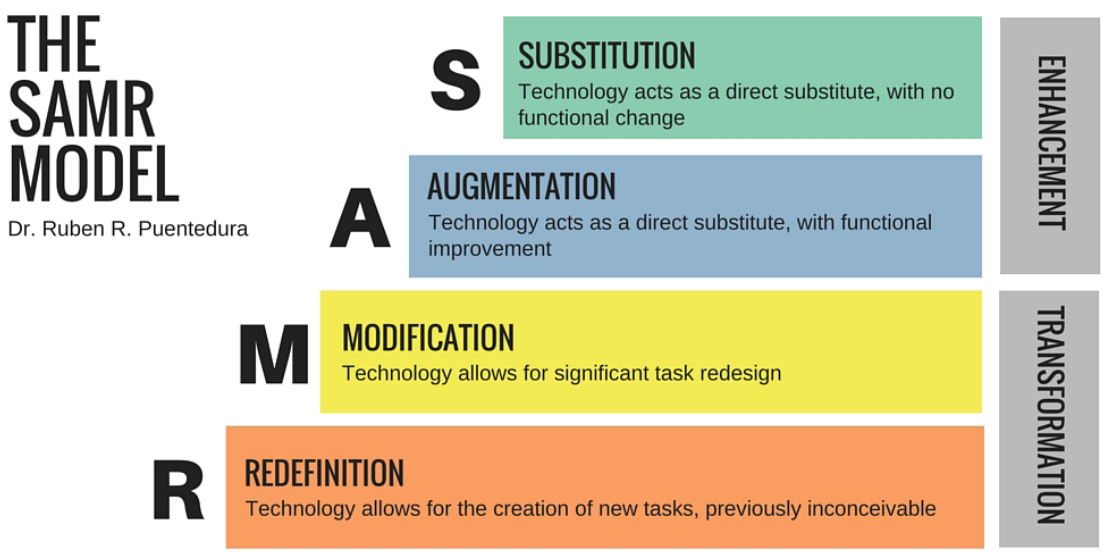


Figure 1. The SAMR model (2006)

Viewed ecologically, this reflects a reductionist view of development. It separates competence from the systems that shape it, including institutional support, professional development, cultural norms, and teacher beliefs. In reality, development is iterative and context-dependent. Practices may evolve, stagnate, or regress depending on changing conditions.

Importantly, the assumption that "redefinition" is always superior does not hold across contexts. In settings with limited infrastructure, low student readiness, or strong pedagogical constraints, lower levels of integration may be more appropriate (Brianza et al., 2022; Tóth et al., 2024).

4.1.3. Underlying assumptions shaping PD

SAMR is based on a technocentric assumption: effective teaching is measured by movement up the hierarchy. This aligns with the microsystem in EST, where focus remains on classroom practice.

The Vietnamese context illustrates this limitation clearly. Interactive boards, for example, are often introduced with expectations of transformative use. In practice, however, they are frequently used for basic substitution, such as displaying slides. This pattern has prompted warnings from the Department of English regarding the overuse of interactive boards without clear pedagogical purpose (Báo Giáo dục và Thời đại, 2015). One contributing factor is that professional development programs tend to emphasize technical skills over pedagogical integration. In rural areas, additional constraints—such as unreliable infrastructure and large class sizes—further restrict opportunities for meaningful experimentation. These examples show how mesosystem factors (e.g., PD design) and exosystem influences (e.g., policy mandates) shape what is possible in practice. While SAMR is popular in PD due to its simplicity, it risks promoting a narrow view of competence that overlooks contextual realities.

4.2. DigCompEdu framework

4.2.1. Conceptualization of competence

The DigCompEdu framework (Redecker, 2017) expands TDC beyond knowledge integration to include professional, pedagogical, and learner-oriented competences. It identifies six areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence (see Fig. 2). This broad scope positions teachers as both instructors and facilitators of students' digital participation. A key strength is its relational approach, linking teacher and learner competence.

However, this orientation also creates tension. By emphasizing learners' competence,

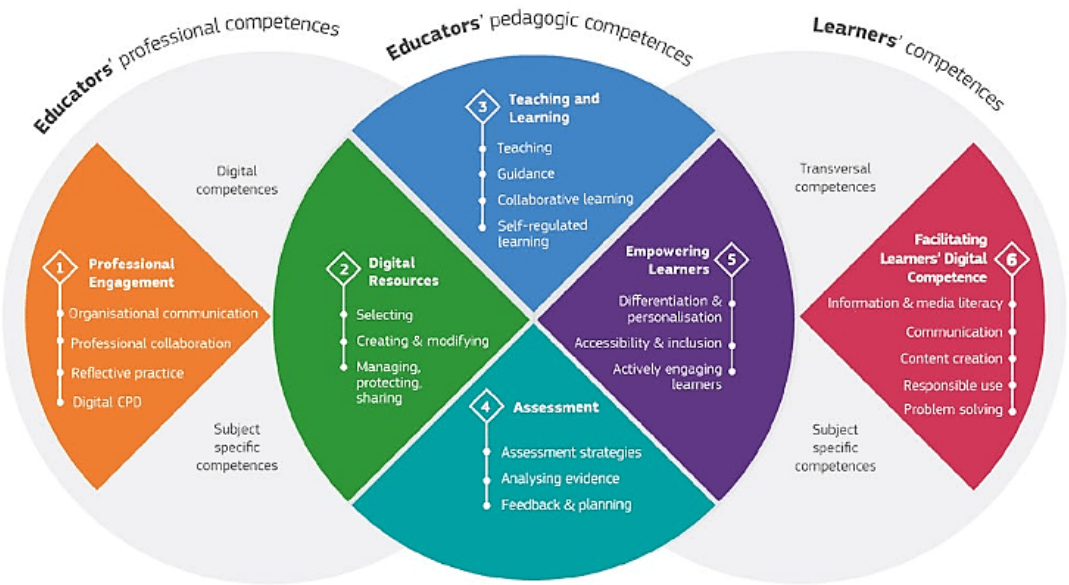


Figure 2. The European Digital Competence Framework for Educators (DigCompEdu)

the framework may create an analytical tendency to evaluate aspects of TDC through learner-related outcomes. Yet, learners operate within their own ecological systems, where teachers are only one influence (Bronfenbrenner, 1979). In practice, teachers may face constraints—such as student readiness, access to tools, or parental expectations—that limit their ability to foster digital competence. These constraints should not be interpreted as deficits in teacher competence.

Empirical studies support these concerns. DigCompEdu shows inconsistencies in how "digital resources" are defined and applied (Reisoğlu & Çebi, 2022). Other research highlights the importance of institutional and contextual factors in shaping competence (Instefjord & Munthe, 2021). These findings suggest that the framework remains insufficiently sensitive to ecological conditions.

In Vietnam, another limitation emerges. Educational priorities often emphasize subject-specific competences, such as communication in English, over digital skills. In such contexts, DigCompEdu's focus on learners' digital competence may overshadow core pedagogical goals.

In addition, the framework lacks a postdigital perspective. It does not fully capture how teachers negotiate and reshape technology in practice. For example, teachers may adopt or reject tools such as AI-generated materials or collaborative platforms based on context. These decisions reflect teacher agency, which the framework only partially addresses.

4.2.2. Model of development

DigCompEdu presents development as a progression from "newcomer" to "pioneer." This model assumes linear and cumulative growth, where higher levels include lower ones (Redecker, 2017).

In practice, development is rarely linear. Teachers may demonstrate high-level competence in one domain but not in others. For example, a teacher trainer may design advanced digital materials but lack classroom experience in applying them. Similarly, competence may shift depending on teaching context, student group, or subject area.

The framework also treats its six domains as discrete. In reality, these domains are interconnected. For instance, professional engagement, for example, shapes teaching design and resource use, which in turn influence learner outcomes.

An ecological lens suggests that this staged model is reductive. It does not capture how competence develops through interactions with institutional conditions, PD opportunities, and sociocultural expectations (Markauskaite et al., 2023). While development is inherently nonlinear and context-dependent, the staged model tends to obscure this complexity.

4.2.3. Underlying Assumptions Shaping PD

DigCompEdu reflects a policy-driven effort to standardize digital competence. This aligns with the macrosystem in EST, where policy frameworks define expectations. Within this logic, competence becomes measurable and comparable. However, this risks reducing development to a fixed outcome rather than an ongoing process.

In addition, the framework was developed through mapping existing models and consulting experts (Caena & Redecker, 2019). Teachers played a limited role in this process. As a result, the framework reflects a top-down perspective.

While DigCompEdu provides a useful common language, its descriptor-based structure may encourage assessment-oriented applications, potentially limiting attention to competence development as an ongoing and context-sensitive process. In PD contexts, this can lead to standardized approaches that overlook differences in resources, access, and teaching conditions.

4.3. The TPACK framework

4.3.1. Conceptualization of competence

The TPACK framework Technological Pedagogical Content Knowledge (Mishra & Koehler, 2006) defines TDC through seven interrelated domains: technological, pedagogical, content knowledge, and their intersections (see Fig. 3). At its core, TPACK conceptualizes

competence as the ability to balance and integrate these domains to design meaningful technology-enhanced learning. This holistic orientation has been widely recognized as a key contribution of the framework, particularly in foregrounding the complexity of teachers' knowledge in digital contexts (Koehler et al., 2013; Voogt et al., 2013).

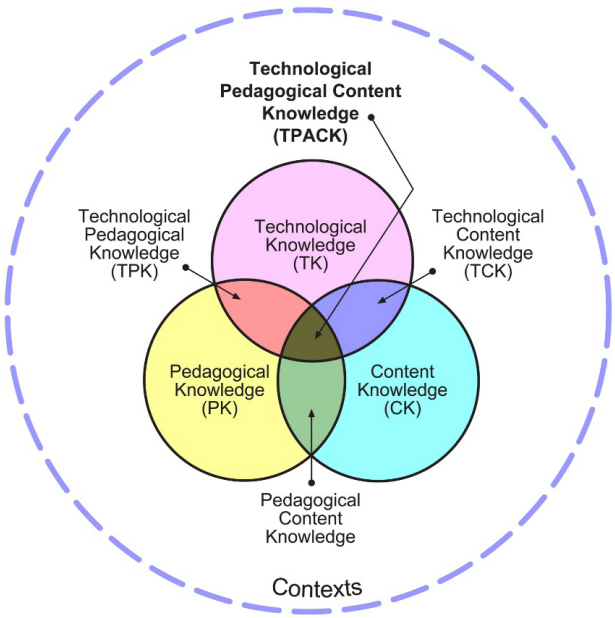


Figure 3.The TPACK framework (2006)

In terms of what competences are emphasized, the framework privileges teachers' mastery of knowledge domains (TK, PK, CK) and their intersections (TPK, TCK, PCK, and integrative TPACK). However, as noted in prior analyses (Graham, 2011), while TPACK emphasizes integration, it retains an underlying structure in which these domains remain conceptually distinguishable. As a result, integration is often treated as the alignment of predefined components rather than as an emergent, context-dependent process. Across the analysed TPACK literature, competence therefore tends to be represented less as situated practice and more as a structured knowledge base that can, in principle, be identified, developed, and evaluated (Archambault & Barnett, 2010).

4.3.2. Model of development

In terms of how development is understood, TPACK suggests that teacher growth occurs through the expansion and integration of its domains, particularly as educators learn to strategically connect technology with pedagogy and content. However, the model conceptualizes this growth largely as an additive or combinatory process rather than one shaped by teachers' broader professional ecology. This interpretation is consistent across the analysed corpus, where development is implied through increasing coherence among knowledge domains rather than explicitly theorized as a temporal or context-responsive process (Voogt et al., 2013).

This orientation has implications for professional development. It can lead to approaches that focus on acquiring and integrating knowledge domains, without fully addressing the situated and evolving nature of teachers' practice. Across ecological levels, this represents a limitation. Although TPACK acknowledges interdependence between domains, it abstracts these relations away from the multi-layered systems—such as collegial networks, institutional structures, policy environments, and cultural norms—that shape teachers' engagement with technology. These systemic conditions play a decisive role in whether teachers can meaningfully enact the integration of TPACK domains.

Moreover, TPACK does not provide a clear account of how competence develops over time, particularly in relation to changing contexts and evolving professional demands. As a result, temporal dimensions of teacher learning remain under-theorized within the framework.

4.3.3. Underlying assumptions shaping PD

From an ecological perspective, TPACK primarily operates at the level of the individual teacher's knowledge base, offering limited engagement with broader systemic factors such as institutional conditions, policy environments, or temporal development. The underlying logic of the framework positions competence as knowledge integration rooted in teacher cognition and individual expertise. This orientation aligns closely with the microsystem in EST, where teachers' immediate interactions with students, content, and digital tools are foregrounded.

However, across the analysed literature,

Table 2. Comparative analysis of TDC frameworks through an ecological–postdigital lens

Dimension	SAMR	DigCompEdu	TPACK
Primary focus	Technology use level	Competence descriptors	Knowledge integration
View of development	Linear hierarchy	Progressive proficiency stages	Additive / integrative growth
Unit of competence	Classroom practice	Teacher and learner competences	Teacher knowledge domains
Role of context	Implicit, minimal	Acknowledged but under-theorized	Largely abstracted
Alignment with EST	Microsystem dominant	Macro- and microsystem emphasis	Microsystem dominant
Postdigital sensitivity	Low (technocentric)	Moderate (human–tech focus)	Limited (cognitive emphasis)
Key limitation	Decontextualized hierarchy	Standardization over agency	Neglect of systemic forces
PD implication	Move up the ladder	Achieve descriptors	Develop integrated knowledge

comparatively less attention is given to mesosystem and exosystem dynamics, such as institutional professional development structures, policy frameworks, and resource infrastructures that shape teachers' opportunities for technology integration. This suggests that while TPACK effectively captures the internal complexity of teacher knowledge, it provides a more limited account of how such knowledge is enabled, constrained, and transformed across broader systems.

The Vietnamese context illustrates this limitation. Existing studies indicate that professional development activities—including peer observation, institutional ICT initiatives, and evaluation systems—play a significant role in shaping teachers' technology practices (Moore, Nguyen, & Nguyen, 2023). In this sense, TPACK offers a valuable but partial perspective: it captures the complexity of knowledge integration but underrepresents the systemic and relational conditions through which TDC is enacted and developed over time.

4.4. Cross-Framework analysis through EST

SAMR, DigCompEdu, and TPACK represent different approaches to TDC. However, they share a common tendency to treat competence as structured, segmented, and measurable. SAMR presents a hierarchical model of technology use. DigCompEdu offers descriptor-based progression across domains. TPACK emphasizes knowledge integration. Despite these differences, all three frameworks assume that competence can be defined and assessed in stable terms.

From an ecological–postdigital perspective, this is a key limitation. These models prioritize structure over context and measurement over process. They may underrepresent certain dynamic, relational, and evolving dimensions of TDC development that become visible through ecological and postdigital perspectives.

For professional development, the implications are significant. Programs based on these frameworks may emphasize progression, coverage, or integration. However, they may overlook the complex and context-sensitive ways teachers develop competence in practice. As a result, these frameworks reflect a broader tension: they offer clarity and structure, but risk reducing competence to a measurable product rather than a lived, evolving process. These observations should be understood as theoretical interpretations derived from the selected

analytical lens rather than definitive evaluations of the frameworks themselves.

5. Discussions

This section provides a theoretically grounded interpretation of the findings. As a conceptual study, the insights are analytical rather than empirically generalizable. Rather than rejecting the selected frameworks in practice, the critique highlights assumptions and limitations that become visible when the frameworks are examined through an ecological–postdigital lens. Accordingly, the analysis identifies dimensions of competence that may receive less attention within framework-based approaches.

5.1. TDC as a fragmented and ecologically partial construct

The analysis shows that each framework offers only a partial view of TDC. TPACK emphasizes knowledge integration and highlights important aspects of teacher expertise. However, its constructs often overlap in practice, reducing clarity and limiting practical guidance. DigCompEdu expands the scope to include digital participation and transversal competences, but its learner-centred orientation shifts attention away from teachers' situated realities. SAMR, while simple and accessible, reduces complex pedagogical decisions to a linear model that prioritizes progression over reflection.

Taken together, these limitations suggest that TDC is often oversimplified when framed within individual models. Competence becomes a set of categories or stages that do not reflect the lived realities of teaching, especially in uneven or resource-constrained contexts.

At the same time, the value of these frameworks lies in their combination rather than isolation. TPACK highlights knowledge, SAMR focuses on practice, and DigCompEdu reflects policy priorities. Together, they offer insights into different dimensions of TDC. However, this multiplicity can also create confusion. Teachers may struggle to determine what counts as competence or how development should be understood—whether as accumulating skills, integrating knowledge, or progressing through levels.

From an EST perspective, this reveals a key limitation. PD, indeed, should not focus on helping teachers "fit" a framework. Instead, it should support them in navigating the multiple systems that shape their practice. These include classroom dynamics, institutional conditions, and broader cultural expectations.

5.2. Context, agency, and the limits of universal professional development

The illustrative case of Vietnam shows that competence is not an individual attribute alone. It is shaped by infrastructure, institutional policies, and cultural norms. Urban teachers often have better access to devices, stable internet, and professional networks. This allows them to align more easily with framework expectations. In contrast, rural teachers face limited resources, fragmented PD, and pressure to adapt without sufficient support (Nguyen, 2018).

This pattern aligns with sociocultural perspectives, which view competence as situated within communities of practice (Lave & Wenger, 1991). Unequal access to resources and support leads to unequal opportunities for development. As a result, standardized PD programs based on imported frameworks may be less responsive to existing inequalities. A postdigital perspective further clarifies this issue. Technology, society, and practice are inseparable and constantly evolving. Competence does not develop in isolation. It emerges from ongoing interactions between technological change, institutional structures, and teacher practice. These influences include both top-down forces, such as policy reforms, and bottom-up dynamics, such as teacher communities.

This helps explain why framework-based PD often falls short. In Vietnam, TPACK- and DigCompEdu-informed programs are frequently implemented as workshop-based training focused on checklist-style competence (Nguyen, 2018; Moore, Nguyen, & Nguyen, 2023). While such approaches provide structure, they risk reducing development to compliance with predefined standards. This technicist orientation—long

critiqued for equating competence with tool use (Halliday, 1998)—does not prepare teachers for real constraints such as large classes, unstable infrastructure, or diverse learner needs. As a result, the widespread adoption of these frameworks may unintentionally encourage standardized interpretations of competence, which can reduce opportunities for locally responsive adaptation and constrain expressions of teacher agency in some contexts. .

5.3. Reconceptualizing TDC as an ecological-postdigital trajectory

Rather than treating TDC as a stable construct, this study proposes a reconceptualization of TDC as an ecological–postdigital trajectory. From this perspective, competence does not exist in fixed domains or levels. It emerges through interactions between teacher agency and the multiple systems in which practice is situated.

Teacher agency is central to this view. Teachers do not passively acquire competence through frameworks. They actively interpret, adapt, and negotiate digital practices in response to their contexts. This agency operates across systems, including institutional structures, policy demands, and sociocultural expectations.

At the same time, a postdigital perspective emphasizes that these systems are not separate from technology. Technological, social, and pedagogical dimensions are intertwined and continuously evolving. As new tools and practices emerge, teachers' work is not simply extended but reconfigured. These processes unfold over time. Development is therefore non-linear, context-dependent, and historically shaped. TDC is not a level to be reached, but an ongoing trajectory shaped by changing conditions. In this sense, this reconceptualization differs from existing contextual and sociocultural approaches in that it explicitly combines teacher agency, multi-level ecological systems, and postdigital understandings of technological entanglement. While sociocultural perspectives primarily emphasize participation within communities of practice and PDC foregrounds professional capabilities, the ecological–postdigital trajectory conceptualizes competence as emerging across interconnected systems and evolving over time.

This perspective can be characterized by four features (see Fig. 4). First, it is ecologically situated, as competence develops across interacting systems. Second, it is agentic, recognizing teachers as active decision-makers. Third, it is postdigital, acknowledging the entanglement of technology and practice. Fourth, it is temporal and non-linear, viewing development as an evolving process rather than progression toward fixed endpoints.

Compared to existing frameworks, this reconceptualization shifts the focus in three ways. It moves beyond TPACK's emphasis on knowledge by foregrounding situated practice. It rejects SAMR's linear progression in favour of contingent development. It extends DigCompEdu

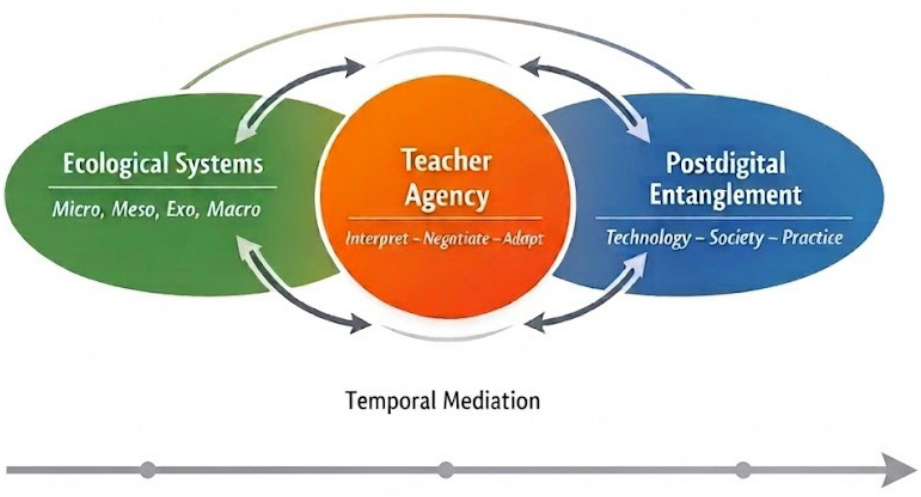


Figure 4. Ecological-postdigital trajectory of teacher digital competence

by emphasizing agency and context over standardized descriptors.

Importantly, this perspective does not replace existing frameworks. Instead, it repositions them as partial representations of a more complex phenomenon. Together, ecological and postdigital lenses show how TDC emerges through ongoing negotiation between teachers and their environments.

Although proposed primarily as a conceptual reframing, the ecological–postdigital trajectory also suggests practical directions for professional learning and research. For professional development, the emphasis shifts from competency checklists toward context-responsive learning, such as collaborative inquiry, peer mentoring, and reflective analysis of technology use in local teaching conditions. In teacher education, the focus moves from mastering fixed digital skills toward adaptive pedagogical judgment in diverse and changing digital environments.

At the policy level, the perspective highlights the importance of enabling conditions such as infrastructure, institutional support, time for collaboration, and access to professional learning networks rather than relying solely on standardized competence targets. For research, it points toward longitudinal and context-sensitive designs that examine how competence evolves through interactions among teacher agency, institutional conditions, and technological change over time. In this sense, the ecological–postdigital trajectory functions as a heuristic for inquiry and reflection, not as a new assessment scale or developmental ladder.

6. Conclusions

This study examined how three influential frameworks—TPACK, DigCompEdu, and SAMR—shape current understandings of TDC. While these models provide useful structure, they tend to frame competence as fixed domains or levels. When treated as sole standards for conceptualizing TDC and TDC development, these models might obscure contextual variability, temporal development, and dependence on teacher agency. In response, the study reconceptualizes TDC as an ecological–postdigital trajectory. From this perspective, competence is not a destination within a framework, but an evolving process shaped by interactions between teachers and their contexts.

This perspective does not replace existing frameworks. Instead, it repositions them as heuristic tools that support reflection when used critically. As a conceptual study, this paper has focused on theoretical analysis. Future research should examine how such trajectories unfold in practice and how they can inform more context-sensitive approaches to professional development.

References

Almas, A. G., Bøyesen, E., & Olofsson, A. D. (2021). Professional digital competence in the postdigital age: Reconceptualizing competence in the face of rapid technological change. *Postdigital Science and Education, 3*(1), 16–35. https://doi.org/10.1007/s42438-020-00204-6

Archambault, L., & Barnett, J. H. (2010). Revisiting technological pedagogical content knowledge: Exploring the TPACK framework. *Computers & Education, 55*(4), 1656–1662. https://doi.org/10.1016/j.compedu.2010.07.009

Báo Giáo dục và Thời đại. (2015, January 13). *Không đánh giá, xếp loại tiết dạy sử dụng bảng tương tác* [No evaluation or ranking of lessons using interactive boards]. https://giaoducthoidai.vn/khong-danh-gia-xep-loai-tiet-day-su-dung-bang-tuong-tac-post451508.html

Barad, K. (2007). *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning.* Duke University Press. https://doi.org/10.1215/9780822388128

Blundell, C. N., Mukherjee, M., & Nykvist, S. (2022). A scoping review of the application of the SAMR model in research. *Computers & Education Open, 3*, Article 100093. https://doi.org/10.1016/j.caeo.2022.100093

Brianza, E., Schmid, M., Tondeur, J., & Petko, D. (2022). Situating TPACK: A systematic literature review of context as a domain of knowledge. *Contemporary Issues in Technology and Teacher Education, 22*(4). https://citejournal.org/volume-22/issue-4-22/general/situating-tpack-a-systematic-literature-

review-of-context-as-a-domain-of-knowledge/

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Harvard University Press.

Bronfenbrenner, U. (1986). Ecology of the family as a context for human development: Research perspectives. *Developmental Psychology, 22*(6), 723–742. https://doi.org/10.1037/0012-1649.22.6.723

Butler-Pascoe, M. E. (2011). The History of CALL: The intertwining paths of technology and second/foreign language teaching. *International Journal of Computer-Assisted Language Learning and Teaching, 1*, 16-32. https://doi.org/10.4018/ijcallt.2011010102

Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (DigCompEdu). *European Journal of Education, 54*(3), 356–369. https://doi.org/10.1111/ejed.12345

Cattaneo, A. A. P., Antonietti, C., & Rauseo, M. (2022). How digitalised are vocational teachers? Assessing digital competence in vocational education and looking at its underlying factors. *Computers & Education, 176*, 104358. https://doi.org/10.1016/j.compedu.2021.104358

Fernández-Batanero, J. M., Montenegro-Rueda, M., Fernández-Cerero, J., & García-Martínez, I. (2022). Digital competences for teacher professional development. Systematic review. *European Journal of Teacher Education, 45*(4), 513–531. https://doi.org/10.1080/02619768.2020.1827389

Fraile, J., Panadero, E., & Pardo, R. (2018). The effect of self-regulation and digital competence on teachers' performance and well-being. *Frontiers in Psychology, 9*, Article 1989.

Garzón-Artacho, E., Sola-Martínez, T., Romero-Rodríguez, J-M., & Gómez García, G. (2021). Teachers' perceptions of digital competence at the lifelong learning stage. *Heliyon, 7*(24), e07513. https://doi.org/10.1016/j.heliyon.2021.e07513

Glister, P. (1997). *Digital literacy*. Wiley.

Graham, C. R. (2011). Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers & Education, 57*(3), 1953–1960. https://doi.org/10.1016/j.compedu.2010.11.010

Gudmundsdottir, G. B., & Hatlevik, O. E. (2018). Newly qualified teachers' professional digital competence: Implications for teacher education. *European Journal of Teacher Education, 41*(2), 214–231. https://doi.org/10.1080/02619768.2017.1416085

Gudmundsdottir, G. B., & Hatlevik, O. E. (2020). "I just Google it" - Developing professional digital competence and preparing student teachers to exercise responsible ICT use. *Nordic Journal of Comparative and International Education (NJCIE), 4*(3-4), 39–55. https://doi.org/10.7577/njcie.3752

Halliday, J. (1998). Technicism, reflective practice and authenticity in teacher education. *Teaching and Teacher Education, 14*(6), 597–605. https://doi.org/10.1016/S0742-051X(98)00010-9

Hamilton, E. R., Rosenberg, J. M., & Akcaoglu, M. (2016). The substitution, augmentation, modification, and redefinition (SAMR) model: A critical review and suggestions for its use. *TechTrends, 60*(5), 433–441. https://doi.org/10.1007/s11528-016-0091-y

Instefjord, E. J., & Munthe, E. (2021). The relation between in-service teachers' digital competence and personal and contextual factors: What matters most? *Computers & Education, 160*, 104052. https://doi.org/10.1016/j.compedu.2020.104052

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

Kuckartz, U. (2014). *Qualitative text analysis: A guide to methods, practice & using software*. SAGE Publications Ltd. https://doi.org/10.4135/9781446288719

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press. https://doi.org/10.1017/CBO9780511815355

Markauskaite, L., Carvalho, L., & Fawns, T. (2023). The role of teachers in a sustainable university: From digital competencies to postdigital capabilities. *Educational Technology Research and Development, 71*(1), 181-198. https://doi.org/10.1007/s11423-023-10199-z

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*, 1017-1054. http://dx.doi.org/10.1111/j.1467-9620.2006.00684.x

Moore, P. J., Nguyen, G. H., Nguyen, Q. V. (2023). Professional standards in CALL teacher training in Vietnam: Towards an ecological approach to CALL integration. In: Tafazoli, D., Picard, M. (Eds.) *Handbook of CALL Teacher Education and Professional Development*. Springer, Singapore. https://doi.org/10.1007/978-981-99-0514-0_27

Nguyen, N. T. H. (2018). Vietnamese teachers' views on a large-scale professional development course on using computer-assisted language learning. In

K. Hashimoto & V. T. Nguyen (Eds.), *Professional development of English language teachers in Asia* (pp. 130–148). Routledge. https://doi.org/10.4324/9781315413259-9

Nguyen, T. H., & Tran, T. (2018). The professional competency of high school English language teachers in Vietnam. *International Journal of Education and Research, 6*(11), 151–164. https://www.ijern.com/journal/2018/November-2018/13.pdf

Olofsson, A. D., Lindberg, J. O., Young Pedersen, A., Arstorp, A.-T., Dalsgaard, C., Einum, E., Caviglia, F., Ilomäki, L., Veermans, M., Häkkinen, P., & Willermark, S. (2021). Digital competence across boundaries—Beyond a common Nordic model of the digitalisation of K-12 schools? *Education Inquiry, 12*(4), 317–328. https://doi.org/10.1080/20004508.2021.1976454

Örtegren, A. (2023). Philosophical underpinnings of digital citizenship through a postdigital lens: Implications for teacher educators' professional digital competence. *Education and Information Technologies, 28*(10), 11463–11483. https://doi.org/10.1007/s10639-023-11807-3

Pham, T. T. N., Tan, C. K., & Lee, K. W. (2018). Exploring teaching English using ICT in Vietnam: The lens of activity theory. *International Journal of Modern Trends in Social Sciences, 1*(3), 15–29.

Puentedura, R. R. (2006, August 18). *Transformation, technology, and education* [Audio podcast episode]. Strengthening Your District Through Technology Workshops. Maine School Superintendents Association. https://hippasus.com/resources/tte/

Raisch, S., & Krakowski, S. (2021). Artificial intelligence and management: The automation–augmentation paradox. *Academy of Management Review, 46*, 192–210.

Redecker, C. (2017). *European framework for the digital competence of educators: DigCompEdu*. Publications Office of the European Union. https://doi.org/10.2760/159770

Reisoğlu, İ., & Çebi, A. (2022). Digital resources as an aspect of teacher professional digital competence: One term, different definitions – a systematic review. *Education and Information Technologies, 28*, 3711–3738. https://doi.org/10.1007/s10639-022-11321-z

Roby, W. B. (2004). Technology in the service of foreign language learning: The case of the language laboratory. In D. Jonassen & M. Driscoll (Eds.), *Handbook of Research on Educational Communications and Technology* (2nd ed., pp. 19). Routledge.https://doi.org/10.4324/9781410609519

Son, J. B. (2018). *Teacher development in technology-enhanced language teaching*. Palgrave Macmillan. https://doi.org/10.1007/978-3-319-75711-7

Tóth, K., Molnár, G., & Kárpáti, A. (2024). Validity evidence regarding the use of DigCompEdu as a self-reflection tool: The case of Hungarian teacher educators. *Practice and Theory in Systems of Education, 19*(1), 27–45.

UNESCO. (2011). *ICT competency standards for teachers: Implementation guidelines*. UNESCO.

Urbaite, G. (2024). The role of technology in modern language education. *EuroGlobal Journal of Linguistics and Language Education, 1*(1), 3-10. https://doi.org/10.69760/w00r1v81

Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological pedagogical content knowledge—A review of the literature. *Journal of Computer Assisted Learning, 29*(2), 109–121. https://doi.org/10.1111/j.1365-2729.2012.00487.x