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Unifying Pedagogical Digital Competence for Primary School Teachers: Theoretical Foundations and Contextual Implications

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Abstract

The accelerating digital transformation of education calls for a coherent and contextually grounded conceptualization of Pedagogical Digital Competence (PDC) for primary school teachers. This paper proposes a theoretical framework of PDC informed by the Iceberg Competence Model, Emotional–Social Competency Theory, and the Multidimensional Input–Output Model. Within this framework, PDC encompasses context-sensitive knowledge, digital–pedagogical skills, and reflective professional attitudes that extend beyond instrumental technology use toward sustainable, learner-centered practice. Using China's Educational Digitalization 2.0 as a focal case, the study analyzes how initiatives such as the "Double Reduction" and "Smart Education" reforms reshape teachers' professional roles, identities, and pedagogical strategies. The paper argues that advancing PDC requires pedagogical soundness, cultural contextualization, and identity transformation. By linking theoretical foundations with policy-driven reforms, this contribution provides a localized, evidence-based framework while offering transferable insights to inform global debates on teacher competence, educational transformation, and the future of teacher professional development.

Keywords: Pedagogical Digital Competence, Primary School Teachers, Educational Informatization, Digital Transformation, Teacher Education

Introduction

Quality education is a central goal of the United Nations' 2030 Agenda for Sustainable Development, and digital transformation is now seen as a key pathway to achieving it (UNESCO, 2023). Technology has not only modernized instruction but has also reshaped pedagogy and children's learning experiences across education systems (Kiryakova & Kozhuharova, 2024). This shift is particularly significant in primary education, where children's

early competences and digital habits for lifelong learning are first established (Robandi et al., 2025). This underscores the importance of examining how digital transformation intersects with the unique developmental needs of young learners.

Within this global shift, China has made significant progress in advancing digital transformation in education. National policies such as the White Paper on Smart Education and the Educational Digitalization 2.0 strategy (MOE of China, 2025) mark a new phase in policy innovation. Earlier initiatives, including the Educational Informatization 2.0 Action Plan (2018), the IT Application Ability Improvement Project 2.0 (2019), and the Standards for Teachers' Digital Literacy (MOE of China, 2022), laid the groundwork for enhancing teachers' digital capacity. More recently, the Action Plan for Deepening Curriculum Reform in Basic Education (2023) emphasized the integration of technology into pedagogy to enrich children's learning. Together, these initiatives illustrate a systematic approach to embedding digitalization within China's primary education system. However, while these policies have established a national framework for teachers' digital literacy, there remains a lack of conceptual clarity regarding pedagogical digital competence (PDC), particularly for primary school teachers (PST) who work with younger learners.

Against this backdrop, PDC has gained prominence as a construct that extends beyond technical proficiency. Coined by From (2017), PDC refers to the knowledge, skills, and attitudes teachers need to integrate digital tools in ways that enhance pedagogy, foster creativity, and support 21st-century learning. Although many frameworks exist (From 2017; Purina-Bieza 2021; Guillén-Gámez et al. 2021; Rozali et al. 2024), there is still no consensus on how PDC should be defined and applied in primary education. This gap makes it difficult for PST to align digital practices with the developmental needs of young learners. Clarifying the scope and application of PDC is therefore critical for supporting effective teaching in digitally transforming education systems.

This paper seeks to address this gap by proposing a theoretically grounded and contextually relevant conceptual framework of PDC for PST. Specifically, it aims to (1) trace the theoretical foundations of competence as a construct, (2) review how PDC has been conceptualized in existing frameworks, and (3) propose a conceptual framework for contextualizing PDC in Chinese primary education. In doing so, the study contributes to the implementation of national education policies in China and enriches international discussions on how PDC can promote equity and quality in primary education. Unlike existing Chinese frameworks that focus primarily on general digital literacy, this study proposes an original conceptual framework of PDC specifically designed for PST. By integrating global theoretical insights with China's policy and classroom contexts, it offers a novel contribution to the social sciences by bridging the gap between digital competence theory and the practical realities of primary education.

Literature Review

Given the fragmented and often inconsistent definitions of PDC across existing scholarship, a comprehensive review is necessary to establish conceptual clarity and provide a robust foundation for the proposed framework. This chapter therefore examines the theoretical roots of competence, the major models that inform its application, and the evolution from digital literacy (DL) to digital competence (DC). It then synthesizes different perspectives on

PDC to clarify its distinctive dimensions for PST. Building on this understanding of competence, the following section explores how the concept has been adapted into the PDC framework for PST.

Competence as a Foundational Concept

The concept of competence has long historical antecedents, with early forms visible in ancient civil service examinations in China and its etymology traced to the Latin competere, meaning"to meet, suit, or be qualified for."By the twentieth century, competence had gained prominence in educational, psychological, and legal discourse, particularly in relation to professional and vocational qualifications, where it denoted the ability to meet defined standards in practice.

In modern psychology, McClelland (1970s) popularized the construct by arguing that competencies are stronger predictors of performance than intelligence tests. Building on this foundation, Spencer and Spencer (1993) defined competence as a cluster of underlying characteristics that enable effective performance. Their Iceberg Model demonstrates that competence extends beyond observable knowledge and skills to include deeper attributes such as motives, traits, and self-concept. These less visible elements are critical for sustained professional effectiveness.

Academic usage often treats competence and competency interchangeably (DEST 2003; Mulder 2014; OECD 2019). Since 2004, however, European Commission publications have tended to standardize competence and its plural form, with competency/competencies declining in use (Sun & Li, 2022). For clarity, this paper consistently uses the term competence.

Contemporary literature generally conceptualizes competence as an integrated construct that combines knowledge, skills, and dispositions required for effective performance in specific tasks or roles. It is typically operationalized through indicators specifying essential knowledge, skills, attitudes, and contextual factors (Salman et al., 2020). Crucially, competence is viewed as dynamic rather than static and can be developed, assessed, and enhanced through education and training.

This multidimensional and developmental perspective provides the foundation for conceptualizing Pedagogical Digital Competence (PDC). It highlights that PDC should not be reduced to technical proficiency but defined as an evolving integration of knowledge, pedagogical practices, and professional dispositions that reflect both educational aims and the developmental needs of primary education.

Theoretical Models Informing Pedagogical Digital Competence

The developmental nature of competence requires theoretical models to explain how different dimensions interact in practice. In the context of PDC, such models help to illuminate the balance between observable skills and deeper professional dispositions that shape teachers' digital–pedagogical practice. Three influential models are particularly relevant: the Iceberg Competence Model (Spencer & Spencer, 1993), Boyatzis' Competency Theory (1982, 2008), and the Competence Theory of Salman et al. (2020). The following subsections outline these models and their implications for understanding PDC in primary education.

Iceberg Competence Model (Spencer & Spencer, 1993)

The Iceberg Competence Model conceptualizes competence as having two distinct levels, much like an iceberg. The visible part above the surface represents competences that are easier to observe and measure, such as knowledge and practical skills. Within primary education, these competences can be seen in teachers' use of digital resources (e.g., interactive whiteboards or educational software), their ability to design age-appropriate lessons, and their classroom communication practices.

Below the waterline lie deeper, less visible components of competence, including self-concept, traits, and motives. These dimensions are harder to cultivate and evaluate, yet they are essential for sustained professional effectiveness. According to Spencer and Spencer (1993), self-concept reflects values and attitudes, traits capture enduring behavioral characteristics, and motives refer to the internal drives that orient individuals toward particular goals.

This layered model anticipated the widely adopted KSA (knowledge, skills, attitudes) framework, highlighting that competence cannot be reduced to technical abilities alone. For PDC, it underscores that effective digital pedagogy requires not only observable technical proficiency but also reflective orientations and intrinsic motivation to use technology in ways that advance pupils' learning and development (see Figure 1).

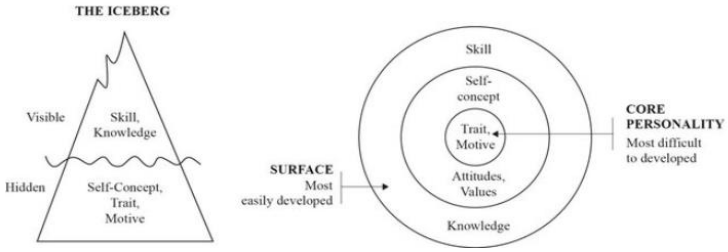

Figure 1. The Iceberg Competence Model (Spencer & Spencer, 1993).

Boyatzis' Competency Theory (1982, 2008)

Boyatzis (1982) advanced competence theory by distinguishing between threshold competencies, which represent the basic knowledge and skills necessary for adequate performance, and performance competencies, which involve deeper psychological and motivational attributes that distinguish high performers. His later work (2008) emphasized emotional and social intelligence, including self-awareness, regulation, empathy, and relationship management, as crucial for professional success.

Applied to education, this model suggests that competence extends beyond technical knowledge to encompass the ability to manage relationships, adapt to challenges, and foster positive learning environments. In the context of PDC, this indicates that teachers require not only digital and pedagogical expertise but also emotional resilience, adaptability, and the capacity to create inclusive and engaging classroom climates in digitally mediated settings.

The Competence Theory of Salman et al. (2020)

Salman et al. (2020) proposed a comprehensive model of competence that distinguishes between hard and soft domains and organizes them within an input–output framework. Inputs include personal attributes, knowledge, skills, and attitudes, while outputs are reflected in effective performance outcomes, both tangible and intangible. This structure highlights that competence is not a static trait but a developmental construct that can be nurtured and systematically assessed.

The model reinforces the idea that competence is best understood as the integration of knowledge, skills, and attitudes (KSA). In the context of PDC, it provides a systematic basis for organizing teachers' digital–pedagogical competences and for assessing how these competences translate into both classroom practices and broader professional dispositions. By emphasizing developmental pathways, the model also points to the potential for teachers' PDC to be progressively enhanced through targeted training and reflective practice (see Figure 2).

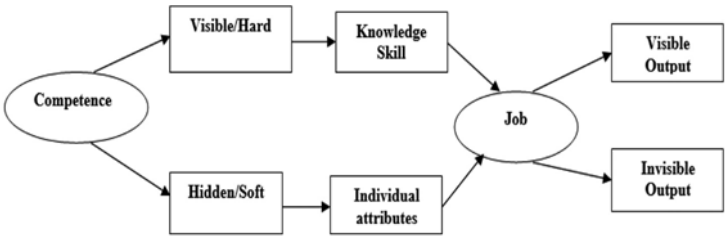

Figure 2. The competence Theory (Salman et al., 2020).

Integration of Competence Theories for Understanding Pedagogical Digital Competence

The Iceberg Competence Model (Spencer & Spencer, 1993), Boyatzis' Competency Theory (1982, 2008), and Salman et al.'s Competence Theory collectively emphasize that competence is a multidimensional construct integrating observable skills with deeper personal, emotional, and motivational dimensions. For PDC, this means that effective digital pedagogy requires not only technical proficiency but also pedagogical judgment, reflective practice, and professional dispositions that enable teachers to adapt to the dynamic challenges of primary education.

Recent empirical studies reinforce the relevance of these foundational perspectives. Zhang and Wu (2025) highlight that teachers' adaptive competence relies on the dynamic integration of knowledge, skills, and attitudes across diverse classroom contexts. Kart and Şimşek (2024) frame competence as a tripartite structure of cognitive, practical, and attitudinal elements, providing further evidence of its broad applicability. Chifla-Villón et al. (2025) develop and validate a multidimensional framework of teachers' digital competence that explicitly incorporates digital–pedagogical knowledge, practical skills, and reflective professional attitudes.

In hence, these classical models and contemporary studies confirm that competence is both multidimensional and developmental. They offer a robust theoretical foundation for understanding and enhancing PDC, linking enduring conceptual insights with current empirical validation and thereby providing a comprehensive basis for framing teachers' digital–pedagogical growth.

From Digital Literacy to Digital Competence

Digital competence (DC) has become a central concept in both education and policy, yet its definition remains contested across frameworks and research traditions. The European Union identifies DC as one of the Eight Key Competences for Lifelong Learning, defining it as the confident and critical use of digital technologies through the integration of knowledge, skills, and attitudes (EC 2007, 2018). Academic perspectives range from narrow views of DC as technical tool-based skills (Lakkala et al., 2011) to broader multidimensional constructs that encompass critical awareness, strategic decision-making, and social responsibility (Ferrari 2012; Cabero-Almenara et al. 2023; Althubyani 2024; Ma and Ismail 2025). This diversity has led some scholars to describe DC as a"terminological maze" with significant overlaps between digital, media, and information literacy (Spante et al., 2018).

Policy frameworks have attempted to clarify this ambiguity. The DigComp framework (EC, 2013) and its updates, such as DigComp 2.2 (Vuorikari et al., 2022) and DigCompEdu (Redecker, 2017), categorize digital competences into domains and progression levels, offering systematic benchmarks for educational contexts. Scholars emphasize, however, that DC must extend beyond technical proficiency to include pedagogical application, reflective attitudes, and professional development (Falloon 2020; Guillén-Gámez and Mayorga-Fernández 2020).

By contrast, the concept of digital literacy (DL) originates from the broader literacy tradition and was later extended to digital contexts. Gilster (1997) first defined DL as the ability to critically and creatively use digital resources, while UNESCO (2025) regards it as a foundational skill for employment, citizenship, and lifelong learning. In practice, DL is often treated as the ability to access, evaluate, and produce digital content, providing the basis on which more advanced competences are developed.

In China, the Standards for Teachers' Digital Literacy (MOE of China, 2022) marked a significant milestone by defining DL as the awareness, abilities, and responsibilities required to use digital technologies for resource acquisition, evaluation, problem-solving, and pedagogical innovation. Building on this foundation, scholars distinguish DL as a set of basic capabilities and DC as a more advanced, multidimensional competence that incorporates ethical awareness, cybersecurity, and professional responsibility (Yang 2022; Luo and Zheng 2023). For example, Wang and Tu (2023) argue that teachers' DC involves not only transmitting ICT knowledge but also guiding students to leverage digital resources for lifelong learning, while Tong and Liu (2023) emphasize cognitive flexibility, problem-solving, and reflective attitudes as essential for pre-service teachers' digital readiness.

In summary, DC and DL share common components of knowledge, skills, and attitudes, but their emphases diverge. DC aligns more closely with professional, social, and pedagogical applications, whereas DL stems from traditional literacy and highlights critical engagement with digital information. This relationship can be illustrated through a conceptual overlap model (see Figure 3). Clarifying this relationship is crucial for framing PDC in ways that reflect both international discourse and the specific pedagogical needs of Chinese PST.

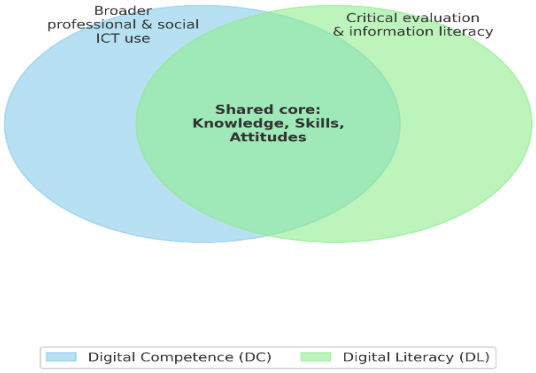

Figure 3. Conceptual Overlap and Distinctions Between DC and DL.

Understanding Pedagogical Digital Competence

Although numerous studies have examined digital competence in educational contexts, a degree of inconsistency remains between the general expectations of DC and the pedagogical dimensions specifically required of teachers. As China advances toward the Educational Informatization 2.0 phase, it becomes essential to reconceptualize teacher professional development. This shift requires moving away from a narrow focus on basic DL and towards PDC, which represents a more integrated and pedagogically oriented form of teachers' digital competences.

Recent policy reforms have underscored the importance of this transformation. The Action Plan for Deepening Curriculum and Instruction Reform in Basic Education (MOE of China, 2023) calls for the strategic use of digital technologies to improve teaching quality, stimulate pedagogical innovation, and enhance learning outcomes. At the international level, the 2025 World Digital Education Conference, aligned with UNESCO's Global Initiative on the Transformation of Education, reaffirmed the transformative role of intelligent technologies in reshaping educational practices and ecosystems. Therefore, these developments highlight PDC as a competence domain that is both nationally contextualized and globally relevant, placing teachers at the forefront of educational change in the digital era.

Scholars have proposed different perspectives on PDC. From (2017) conceptualized it as consisting of two interrelated dimensions: pedagogical competence and digital competence. Purina-Bieza (2021) argued that any comprehensive understanding of PDC must acknowledge both digital literacy and pedagogical competence as its foundation. Mezentceva et al. (2020) observed that educators' often ambiguous perception of PDC stems from the lack of universally accepted frameworks that capture its scope. Instefjord and Munthe (2016) described PDC as a blend of "hard" and "soft" skills, encompassing both technical competences and general pedagogical capacities. Other frameworks distinguish between instrumental competences, such as searching for information, producing content, and facilitating communication, and pedagogical competences that ensure meaningful integration into teaching practices (Navarro et al. 2016; Redecker 2017; Wu and Ren 2023).

Despite these variations, three core elements consistently emerge across the literature:

- Knowledge of pedagogical and psychological principles that inform digital education, providing a theoretical basis for instructional design and decision-making.
- Skills to evaluate digital content critically and to apply appropriate technological and instructional solutions that enhance teaching and learning.
- Attitudes that demonstrate openness, reflection, and a sustained commitment to integrating digital technologies in ways that are pedagogically meaningful and contextually appropriate.

From (2017) further argued that PDC represents a more advanced stage of DC, encompassing not only technical and cognitive skills but also attitudes and reflective integration of ICT into pedagogy. Similarly, Lázaro-Cantabrana et al. (2019) defined PDC as"a combination of skills, abilities and attitudes required for educators to effectively embed digital technologies into teaching and ongoing professional growth."

Synthesizing these perspectives, this paper defines PDC as the contextualized integration of knowledge, practical skills, and professional attitudes that enable teachers to make deliberate and pedagogically sound decisions about technology use in teaching. PDC extends beyond technical proficiency to encompass critical thinking, reflective practice, and sustainable digital engagement. Effective digital pedagogy therefore requires not only tool mastery but also the ability to align technological choices with pedagogical aims and the developmental needs of learners (see Figure 4).

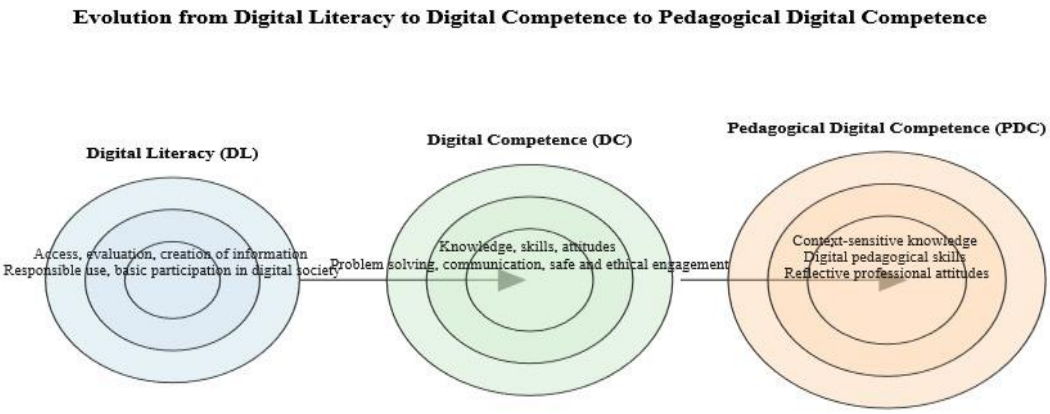

Figure 4. Theoretical Evolution from DL to DC and PDC.

To further clarify these distinctions, Table 1 summarizes the main conceptual differences between DL, DC, and PDC.

Table 1
Conceptual Differences between DL, DC, and PDC

Dimension	Digital Literacy (DL)	Digital Competence (DC)	Pedagogical Digital Competence (PDC)
Core Definition	Ability to access, evaluate, and create digital content across personal, civic, and lifelong learning contexts (UNESCO, 2025). In China (2022), officially defined as encompassing awareness, knowledge, technical skills, social responsibility, and professional growth.	A multidimensional construct integrating knowledge, skills, and attitudes for effective, critical, and creative use of digital technologies across professional, personal, and social domains (EC 2013; Vuorikari et al. 2022).	A contextualized competence that integrates pedagogical knowledge, digital skills, and professional attitudes, enabling teachers to make educationally sound decisions and enhance teaching and learning (Lázaro-Cantabrana et al. 2019; Wu and Ren 2023).
Primary Focus	Foundational use of digital tools and information processing.	Context-specific and multi-domain digital applications.	Technology integration in educational contexts and pedagogical innovation.
Main Components	Access, analyze, create, and communicate information.	Knowledge, skills, and attitudes in combination.	Developmentally informed knowledge, digital–pedagogical skills, reflective and innovative attitudes.
Scope of Application	Citizens, learners, and professionals.	All societal sectors.	Teachers and educational practitioners.
Policy Context	Widely used in UNESCO frameworks; formally adopted in China through the 2022 teacher DL standard.	Prominent in European policy (e.g., DigComp 2.2), increasingly applied in China since 2017.	Mainly used in teacher education and digital pedagogy policies (e.g., DigCompEdu; China's Educational Digitalization 2.0).

The evolution from DL to DC and ultimately to PDC demonstrates a progression from basic digital engagement to pedagogically embedded professional practice. This literature review clarifies the conceptual foundations required for contextualizing PDC in primary education. The following section outlines the methodological approach adopted in this study to further examine and structure PDC for Chinese PST.

Methodology

Given its conceptual and theoretical orientation, the methodology focuses on synthesizing insights from competence theories, policy frameworks, and empirical studies to develop a

context-sensitive understanding of PDC. The chapter is structured into five parts: research design, data sources, analytical strategy, rationale for methodological choice, and literature search procedure.

Research Design

This study adopts a conceptual and theoretical research design rather than an empirical approach. Its primary aim is to clarify the construct of PDC in the context of primary education. The study does not rely on surveys or experiments; instead, it applies a process of conceptual synthesis to integrate insights from international frameworks, competence theories, and Chinese education reforms. Such a design is appropriate for addressing the current lack of definitional clarity and for constructing a context-sensitive framework that responds to the realities of PST.

Data Sources

This study drew upon three complementary sources of evidence. First, major Chinese policy documents were examined to establish the institutional context in which teachers' digital competence is defined and promoted. These included the Educational Informatization 2.0 Action Plan (2018), the IT Application Ability Improvement Project 2.0 (2019), the Standards for Teachers' Digital Literacy (MOE of China, 2022), and the Action Plan for Deepening Curriculum and Instruction Reform in Basic Education (2023). The China Smart Education White Paper (2025) was also included, as it identifies 2025 as the formal starting year of "Smart Education." To enable global comparison, international frameworks such as the European Commission's DigComp (2013), DigComp 2.2 (Vuorikari et al., 2022), and DigCompEdu (Redecker, 2017), as well as UNESCO's digital education initiatives (2023, 2025), were reviewed.

Second, theoretical literature on competence was considered to provide a conceptual foundation. This included Boyatzis' Competency Theory (1982, 2008), Spencer and Spencer's Iceberg Model (1993), and Salman et al.'s Competence Theory (2020). Together, these models conceptualize competence as the integration of knowledge, skills, and attitudes, offering a useful lens for interpreting teachers' digital practices.

Finally, empirical studies published between 2016 and 2025 were analyzed to contextualize these theoretical insights. These studies addressed issues such as digital readiness, competence assessment, and pedagogical application. Examples include research applying DigCompEdu in China (Du & Huang, 2021), analyses of challenges in digital teaching (Zhu et al. 2022; Tong and Liu 2023), and reports highlighting strengths in professional development and digital responsibility (Song, 2023). In addition, national-level survey data (CIEFR-PKU, 2023) provided a broader statistical perspective. To ensure comprehensiveness, a structured search of relevant literature was conducted, the procedures of which are outlined in the following section.

Analytical Strategy

The analysis adopted a comparative framework analysis with conceptual synthesis. The analytical process went through three iterative stages:

- Mapping: Mapping different definitions of DL, DC and PDC and identifying their overlaps, divergences and contextual emphases across different frameworks.

- Theorizing: Using competence models (Boyatzis 1982, 2008; Spencer and Spencer 1993; Salman et al. 2020) as interpretive frameworks, together with the Knowledge–Skills–Attitudes (KSA) structure, allows for the integration of fragmented perspectives into a more unified theoretical base, especially in the context of primary education.
- Contextualizing: Situating the synthesized findings in the Chinese primary education context, and grounding them in developmental psychology (Piaget 1972; Vygotsky 1978) as well as current reforms like the "Double Reduction" policy (2021) and the China Smart Education Platform (2022), allows the conceptualization of PDC to be closely aligned with the practical realities and developmental needs of PST.

Rationale for Methodological Choice

The choice of a conceptual synthesis approach is based on two considerations. First, although research on PDC has grown in recent years, the literature remains fragmented, and no single framework sufficiently addresses both the pedagogical and developmental dimensions relevant to primary education in China. Bringing together competence theory, policy, and pedagogy is therefore necessary to construct a more holistic perspective. Second, China's rapid digital reforms create an urgent demand for theoretical contributions that can guide teacher training, curriculum reform, and future empirical inquiry. This study responds to that need by integrating international frameworks with Chinese policy priorities in order to propose a unified understanding of PDC. To support this synthesis, a structured search of relevant literature was undertaken; the scope and process of this search are described in the following section.

Literature Search Procedure

To build a comprehensive evidence base, publications were identified through major databases, including Scopus, Web of Science, ERIC, and CNKI. The search focused on key terms such as DL, DC, PDC, and teacher education, and considered studies published between 2010 and 2025. Inclusion criteria emphasized research that addressed teacher competence, digital transformation in education, or conceptual frameworks relevant to primary schooling. In contrast, sources that were purely technical (e.g., software development without pedagogical application) were set aside, as they did not contribute to the study' s focus. This process enabled the review to combine international scholarship with Chinese-language research, ensuring a more balanced coverage of theoretical and contextual perspectives.

The methodological process followed three iterative stages: Mapping, Theorizing, and Contextualizing. As illustrated in Figure 5, the procedure began with mapping the definitions of DL, DC, and PDC, proceeded with theorizing through competence models (Boyatzis 1982, 2008; Spencer and Spencer 1993; Salman et al. 2020), and concluded with contextualizing these insights within Chinese primary education and recent reforms.

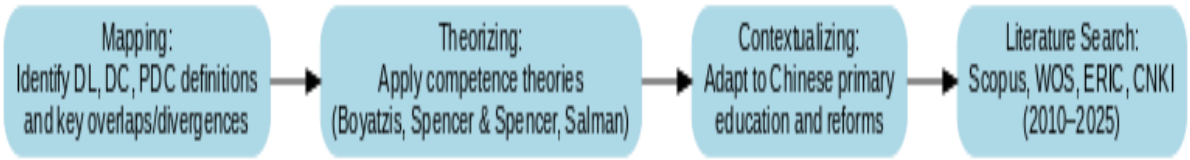

Figure 5. Flowchart of methodological stages.

Discussion and Findings

This section presents the discussion and findings derived from the conceptual synthesis. Building on the theoretical foundations outlined in the literature review and the methodological approach described in the previous chapter, the analysis is organized into four interrelated parts. It begins by establishing a child-centered cognitive foundation for PDC in primary education, followed by an examination of the specific characteristics of PST in China. The third part explores the current state and challenges of PDC among PST, and the final section proposes a conceptual model that synthesizes these dimensions into a coherent framework.

A Child-Centered Cognitive Foundation for Pedagogical Digital Competence in Primary Education

PDC in primary education must be grounded in a nuanced understanding of children's developmental characteristics. Piaget's theory of cognitive development (Piaget & Inhelder, 1972) identifies the primary school years (ages 7–11) as the concrete operational stage, in which children begin to reason logically but remain limited to tangible and visual experiences. This developmental stage implies that digital pedagogy should prioritize interactive, image-rich, and experiential learning rather than abstract or heavily text-based tools. For instance, digital games, simulations, and visual manipulatives can scaffold logical reasoning while sustaining motivation.

Vygotsky's sociocultural theory (1978) complements this perspective through the concept of the Zone of Proximal Development (ZPD), which emphasizes that learning occurs most effectively when tasks slightly exceed children's independent ability but are supported through guidance and collaboration. Digital tools such as adaptive learning platforms, multimedia scaffolds, and collaborative applications can serve as effective mediators, enabling students to engage in developmentally appropriate yet challenging learning experiences. Consequently, PST require not only technical proficiency but also pedagogical sensitivity to align digital tools with children's cognitive and social needs.

The Specificity of Primary School Teachers in China

Understanding PDC also requires attention to the unique characteristics of PST in China. As the largest segment of the teaching profession, PST are generally younger and less experienced than secondary teachers (Zhou & Miao, 2022). Their relatively young age often correlates with stronger digital affinity and openness to experimenting with technology, but limited pre-service preparation and shorter classroom practice sometimes restrict their ability to apply digital tools pedagogically. This tension underscores the importance of targeted professional development.

National reforms have further raised expectations for PST. Following the introduction of the "Double Reduction" policy in 2021 and the rollout of the China Smart Education Platform in 2022, PST are now tasked with enriching classroom teaching, diversifying assessment strategies, and integrating digital resources in developmentally appropriate ways. Unlike secondary teachers, they must balance innovation with protecting younger learners' foundational skills, attention spans, and emotional well-being. As a result, PDC for PST cannot be reduced to technical mastery; it must encompass developmental awareness, adaptive teaching strategies, and ethical facilitation of digital engagement.

Current State and Challenges of Pedagogical Digital Competence among Primary School Teachers

The reform context has also reshaped the current landscape of PDC. Since the "Double Reduction" policy and the establishment of the China Smart Education Platform, the availability of digital resources has expanded significantly. A 2022 national survey by the China Institute of Education Financial Science (CIEFR-PKU, 2023) found that digital technologies are now routine in primary classrooms, with widespread use of smartboards, multimedia resources, and online platforms. However, routine usage does not necessarily translate into high pedagogical digital competence, as meaningful integration remains uneven.

Du and Huang (2021), using the DigCompEdu CheckIn tool, reported that most PST reached the Integrator (B1) level in digital resource use but only the Explorer (A2) level in teaching and assessment. This indicates that while functional competence in device and resource management is relatively strong, deeper pedagogical integration is less developed. Zhu et al. (2022) and Tong and Liu (2023) similarly identified challenges in formative assessment, differentiated instruction, and digital ethics, noting that many teachers struggled to align technological tools with learning outcomes.

At the same time, some encouraging findings have emerged. Song (2023), drawing on the 2022 Standards for Teachers' Digital Literacy, reported that PST performed relatively well in digital social responsibility and professional development, in some cases surpassing secondary teachers. This suggests that while the transition from technical competence to pedagogical competence remains incomplete, PST are cultivating more responsible and sustainable digital practices.

In summary, these findings reveal that PST operate within a policy environment that simultaneously provides opportunities and imposes new pressures. While access to digital tools has expanded significantly, their integration is not always pedagogically sound or developmentally appropriate. This underscores the importance of reconceptualizing PDC not as functional fluency alone, but as a multidimensional competence that integrates knowledge, skills, and professional attitudes. Building on these insights, the next section presents a conceptual model that synthesizes these dimensions into a coherent framework for PDC in Chinese primary education.

Implications and Conceptual Model of Pedagogical Digital Competence

The preceding analysis highlights three interrelated foundations of Pedagogical PDC for PST in China: the developmental needs of children, the unique demographic and professional characteristics of PST, and the uneven but evolving landscape of digital practice under current reforms. Together, these elements reveal that PDC cannot be reduced to functional mastery of digital tools. Instead, it must be reconceptualized as a multidimensional competence that reflects the complex realities of primary education and the transformative ambitions of national reform.

To visualize this synthesis, Figure 6 presents the conceptual model of PDC in Chinese primary education. It is structured around three interrelated dimensions:

- Context-sensitive knowledge, grounding pedagogical design in developmental psychology and curriculum needs, and enabling teachers to design age-appropriate and

meaningful digital learning experiences.

- Digital–pedagogical skills, integrating digital tools for instruction, assessment, differentiation, and interactive engagement, ensuring that technology supports rather than supplants pedagogy.
- Reflective professional attitudes, encompassing ethical awareness, openness to innovation, and a commitment to sustainable and inclusive digital practice.

This model underscores the transition PST must make from routine technology use toward thoughtful, learner-centered integration that supports both cognitive development and emotional well-being. By situating PDC within the realities of China's policy environment and the developmental needs of primary school students, the model provides a foundation for rethinking teacher training, professional development, and curriculum design in the era of Educational Digitalization 2.0.

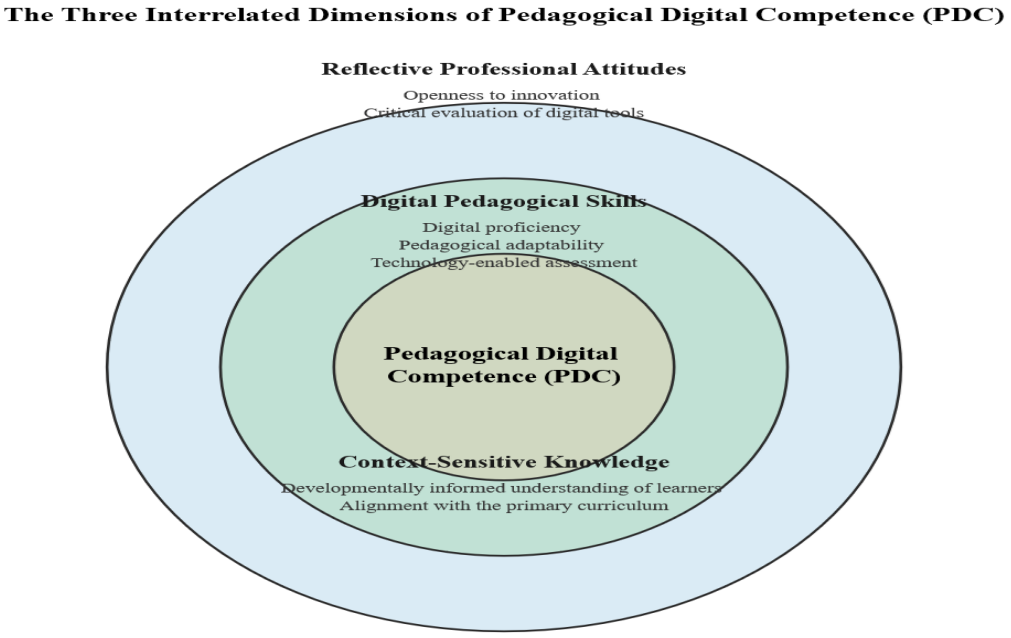

Figure 6. Conceptual model of PDC in the context of Chinese primary education.

Conclusion and Future Directions

This paper has sought to clarify the theoretical foundations and contextual specificities of PDC for PST in China. By synthesizing international frameworks, competence theories, and Chinese educational reforms, it has argued that PDC must be understood as a multidimensional construct rather than a narrow focus on technical proficiency. The analysis highlights that PDC in primary education is shaped by three interrelated factors: children's developmental characteristics, the demographic and professional profile of teachers, and the reform-driven demands of the current policy landscape.

Building on these insights, the study proposes that PDC should be conceptualized as an evolving competence comprising three interdependent dimensions: context-sensitive knowledge, digital–pedagogical skills, and reflective professional attitudes. This conceptualization moves beyond functional uses of technology, underscoring the importance of reflective decision-making, differentiated instruction, and learner well-being. Framing PDC

in this way provides a foundation for more coherent policy design, targeted professional development, and age-appropriate classroom innovation in Chinese primary education.

Looking forward, further research is needed to operationalize this conceptual framework by identifying progression levels, domain-specific indicators, and valid assessment tools tailored to the realities of primary school teaching. Comparative studies across different education systems would also enrich understanding of how PDC develops in diverse contexts, offering opportunities for cross-national dialogue and knowledge exchange. Ultimately, situating PDC within both theoretical traditions and practical demands ensures that it remains responsive to the challenges of digital transformation while aligned with the developmental needs of young learners.

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