



Work Package 1

Theoretical foundation and policies of effective teacher PDC training to support student learning

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Theoretical framing of the EffectiVe effective teacher PDC training to support student self-regulated learning

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Executive Summary

In recent years, the rapid digitalisation of education has led to increased policy attention across the European Union on how digital technologies can be effectively integrated into teaching and learning. Significant investments have been made in digital infrastructure, access to digital resources, and teacher training initiatives. However, evidence shows that the impact of these investments on student learning depends not on technology alone, but on how it is pedagogically used in classroom practice. This has led to growing recognition of the importance of teachers' pedagogical digital competence (PDC) and the need for research-informed approaches to its development.

Responding to this need, the EffectiVe project aims to strengthen the evidence base on how teachers' PDC can be effectively developed and enacted in technology-enhanced learning environments. The project adopts a process-oriented and interdisciplinary perspective that (1) conceptualises PDC as a dynamic competence integrating knowledge, motivation, skills, and practice, (2) investigates how teacher training can support the development of PDC across different contexts, (3) examines how teachers translate competence into classroom practice, particularly in supporting students' self-regulated learning (SRL), and (4) contributes to the development of analytical and methodological approaches for evaluating teacher training effectiveness.

This deliverable provides the theoretical foundation for these efforts by presenting the conceptual framework of PDC developed within the EffectiVe project. It conceptualises PDC as a dynamic interplay between teachers' cognitive and affective-motivational dispositions, their situation-specific professional skills, and their enacted teaching practices. A central contribution of the framework is the integration of self-regulated learning (SRL) as a cross-cutting mechanism that links teacher learning, pedagogical decision-making, and classroom practice. In addition, the framework explicitly incorporates motivational perspectives, such as self-efficacy and expectancy-value-cost theory, to explain how teachers' beliefs influence their engagement with digital pedagogy and the implementation of innovative practices.

Overall, this deliverable contributes to the EffectiVe project by providing a coherent conceptual and analytical foundation for subsequent work packages. It establishes a shared understanding of pedagogical digital competence, clarifies the mechanisms through which teacher training is expected to influence practice and student learning, and supports the interpretation and comparison of findings across national contexts.

1. Introduction

Digital transformation is reshaping educational systems across Europe, placing increasing demands on teachers to design, implement, and adapt learning in technology-enhanced environments. Beyond the use of digital tools, this shift requires teachers to integrate pedagogical, technological, and subject-specific knowledge, while responding to diverse learner needs and rapidly changing instructional contexts. As a result, the concept of **pedagogical digital competence** (PDC) has gained prominence in research, policy, and teacher education.

At the same time, existing approaches to PDC have often focused primarily on knowledge and skills, with less attention to the motivational and self-regulatory processes that shape how teachers engage with digital pedagogy and translate competence into practice. Addressing this gap is particularly important in technology-rich learning environments, where both teachers and students are required to manage complexity, regulate learning processes, and adapt to evolving demands.

This deliverable presents the **conceptual framework developed in the EffectiVe project**, in which PDC is understood as a dynamic, process-oriented competence that integrates cognitive and affective-motivational dispositions, situation-specific skills, and enacted teaching practice. A central contribution of the project is the **integration of self-regulated learning (SRL) as a cross-cutting mechanism that connects teacher learning, pedagogical decision-making, and classroom practice**, as well as the explicit consideration of **motivational beliefs** as a condition for the development and enactment of PDC.

The report is structured as follows. **Chapter 2** introduces the conceptualization of PDC in EffectiVe, outlining its core components and theoretical foundations. **Chapter 3** builds on this by presenting a competence development model and a training-to-impact pathway that links teacher professional development to classroom practice and student outcomes. **Chapter 4** shifts the focus to the classroom level, examining how PDC is enacted through teaching strategies that support students' self-regulated learning in technology-enhanced environments. Finally, **Chapter 5** synthesizes the main lessons learned and outlines policy pathways for teacher education and professional development.

2. Conceptualizing Pedagogical Digital Competence in the EffectiVe project

This chapter outlines the conceptualization of PDC adopted in the EffectiVe project. It updates and extends the definition proposed in Deliverable 1.1 (Zabolotna et al, 2024) and grounds its core components in the project's theoretical and empirical work to date. In EffectiVe, PDC is understood as a **dynamic form of teacher competence that develops through the interaction of cognitive and affective-motivational dispositions, situation-specific professional skills, and enacted teaching practice**. Drawing on process-oriented models of teacher competence (Blömeke et al., 2015; Skantz-Åberg et al., 2022), the chapter introduces these components and clarifies the role of SRL as a cross-cutting lens supporting their development and enactment.

2.1 Definition and rationale

The overarching concept of Pedagogical Digital Competence (PDC) in the EffectiVe project is defined as the **dynamic interplay of teachers' cognitive and affective-motivational dispositions, situation-specific skills, and enacted pedagogical practices in designing, implementing, and adapting teaching in technology-enriched learning environments**. These resources are shaped by professional contexts and become visible in situated teaching activity. Drawing on process-oriented competence models (Blömeke et al., 2015; Skantz-Åberg et al., 2022), PDC is understood not as a fixed competence profile, but as an evolving competence that emerges through the activation, integration, and adaptation of cognitive, motivational, and situational resources over time.

This process-oriented conceptualization is motivated by growing evidence that teachers' professional competence cannot be fully captured by stable knowledge or attitudes alone. Rather, effective technology integration requires teachers to continuously interpret classroom situations, regulate their own learning and working, and adapt pedagogical strategies in response to changing instructional demands and contextual challenges and constraints (Burns & Kanninen, 2023; From, 2017; Purina-Bieza, 2021). Accordingly, the development and enactment of PDC depend not only on what teachers know or believe, but also on how they mobilize these resources in practice, how they respond to feedback from teaching situations, and how professional contexts shape and constrain their actions.

Within EffectiVe, PDC is therefore understood as comprising interrelated components - **cognitive and affective-motivational dispositions, situation-specific skills (especially perception, interpretation, and decision-making), and performance** - that are mutually influencing and situated. These components form a system in which changes in one element

may trigger adjustments in others, ultimately shaping teachers' pedagogical actions and student learning opportunities (Blömeke et al., 2015). Central to this system is teachers' capacity for **self-regulated learning (SRL)**, which operates as a cross-cutting mechanism enabling teachers to integrate knowledge, motivation, and skills, and to sustain professional learning in digitally rich and evolving educational environments.

Figure 1 illustrates the EffectiVe PDC conceptualization and highlights its core innovation: **PDC is represented as a dynamic process of activation, integration, and adaptation rather than as a fixed competence profile.** It visualizes how teachers' cognitive, motivational, and situational resources are engaged in authentic teaching contexts and how SRL supports their transformation into pedagogical action. This system-oriented perspective provides the conceptual foundation for the project and informs the design of its teacher training, assessment, and research activities

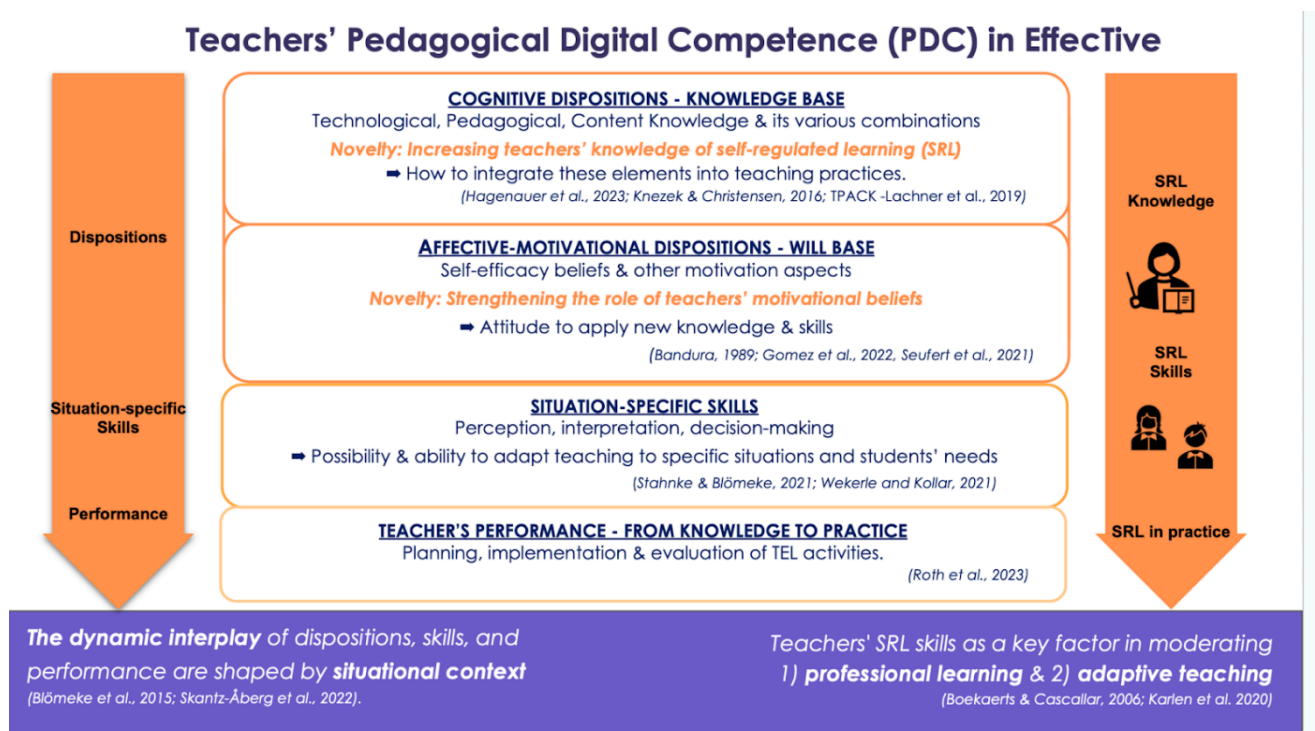


Figure 1: PDC in the EffectiVe project

The following sections elaborate the core components of PDC in more detail. Drawing on established theoretical models, they clarify how cognitive and affective-motivational dispositions, situation-specific skills, and performance are conceptualized in EffectiVe, and how SRL functions as a unifying lens across these elements

2.2 Core components of PDC: dispositions, situation-specific skills, and practice

Building on the overarching definition above, this section elaborates the core components of PDC in the EffectiVe framework. The aim is to clarify the distinct functions of cognitive and affective-motivational dispositions, situation-specific skills, and enacted practice within a dynamic competence process.

2.2.1. Cognitive dispositions - knowledge base

Within the EffectiVe PDC conceptualization, teachers' cognitive and affective-motivational dispositions form a foundational layer that shapes how technology-enhanced pedagogy is understood, approached, and pedagogically enacted. These dispositions provide the internal resources that teachers draw upon when interpreting pedagogical challenges, engaging with digital technologies, and regulating their professional learning. Rather than being static personal characteristics, cognitive and affective-motivational dispositions are understood as dynamic and context-sensitive, developing over time through professional experience, learning opportunities, and engagement with practice.

Cognitive dispositions refer to the existing knowledge a teacher possesses and the developing knowledge that is constructed through professional development and practical implementation. The OECD (2025a) Teaching Compass foregrounds the idea that teachers' knowledge is increasingly characterized by its **adaptive and epistemic qualities**. Teachers are expected to engage with uncertainty, critically evaluate information, and continuously update their understanding in light of research, data, and professional experience. Interpreted as cognitive dispositions, these expectations point to knowledge that is not merely possessed but **mobilized and transformed** through reflective engagement with practice. In this sense, **teachers' cognitive dispositions are closely connected to their own self-regulated learning processes**. Through planning, monitoring, and reflecting, teachers regulate their professional learning, evaluate instructional decisions, and adapt their knowledge to new pedagogical challenges. Cognitive dispositions therefore encompass teachers' readiness to learn, unlearn, and relearn, as well as their capacity to connect prior knowledge with emerging instructional demands.

The OECD emphasizes that teachers draw on multiple, interrelated knowledge domains, including disciplinary, pedagogical, curricular, learner-related, and contextual knowledge. Together they enable informed professional judgment. Such a conception aligns with an understanding of cognitive dispositions as **integrated and situationally activated**. In the EffectiVe project, these identified knowledge demands are addressed through a conceptualization of teachers' cognitive dispositions that emphasizes the **integration and activation of knowledge in practice**. To theorize how teachers' knowledge is structured and

mobilized in digitally mediated pedagogy, we draw on the **Technological Pedagogical Content Knowledge (TPACK) framework** (Mishra & Koehler, 2006; Mishra et al., 2023). TPACK provides a conceptual lens for understanding teachers' knowledge as an interrelated system of content, pedagogical, and technological understanding that is dynamically enacted in teaching situations.

Viewed through this lens, teachers' cognitive dispositions are not defined by isolated knowledge domains, but by their **capacity to coordinate and adapt knowledge** in response to instructional goals, learner needs, and contextual constraints. TPACK captures this capacity by foregrounding the intersections among knowledge domains, highlighting how effective digital pedagogy depends on teachers' ability to make informed judgments about how technologies can meaningfully support learning within specific content areas. In this sense, TPACK supports a dispositional understanding of teacher knowledge that aligns with the global emphasis on adaptability, integration, and continuous learning, while offering a theoretically grounded way to conceptualize how such knowledge is organized and enacted in practice.

In addition to the more overarching theoretical notions related to teachers' knowledge, the EffectiVe project also follows the DigCompEdu framework (Redecker & Punie, 2017), which offers a comprehensive approach to supporting teachers' digital competence by categorising competence across six areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. This framework provides a structured way to foster educators' abilities to effectively integrate digital tools and resources into their teaching practice. In EffectiVe, the DigCompEdu is used for designing our teacher training interventions in WP2. Although the development of all 22 digital competencies is needed, in our project, we deliberately highlight the areas of **teaching and learning** (the focus on supporting students' SRL in technology-enriched learning), **empowering learners** (the focus on differentiated learning to address the inequity and inclusion), and **facilitating learners' digital competence** with the focus on problem-solving skills.

This emphasis reflects the project's focus on technology-enriched learning environments in which teachers are expected to design and guide learning processes that support students' self-regulated learning, cognitive engagement, inclusion, and problem-solving. In this context, the **teaching and learning area** is especially relevant for how teachers design, orchestrate, and adapt digital learning activities. The **empowering learners area** is particularly important for differentiation, inclusion, and the creation of flexible learning trajectories that respond to learner diversity. The area of **facilitating learners' digital competence** is closely connected to the project's focus on helping students use digital

technologies critically, creatively, and responsibly, while also supporting problem-solving and adaptive participation in digital knowledge practices. Taken together, these emphases show how the EffectiVe project interprets teachers' cognitive dispositions not only as knowledge about technology, but as knowledge for designing supportive, adaptive, and pedagogically meaningful learning environments.

To summarize, within the EffectiVe project, teachers' cognitive dispositions are understood as integrated, developable, and context-sensitive knowledge resources that support well-grounded pedagogical decision-making in technology-rich classrooms. TPACK provides the main theoretical lens for conceptualizing how this knowledge is structured and mobilized in practice, while DigCompEdu offers a complementary framework that informs the design of the project's teacher training interventions. Together, these frameworks provide a strong foundation for the EffectiVe view of pedagogical digital competence as the capacity to design and guide learning in technology-enhanced environments in ways that support students' digital competence, subject learning, and self-regulated learning.

2.2.2. Affective-motivational dispositions - the will base

Within the EffectiVe conceptualization of PDC, affective-motivational dispositions constitute a core component that complements teachers' cognitive dispositions and shapes how effective technology implementation in classroom is taken up, sustained, and further developed over time (Klassen & Tze, 2014; Knezek & Christensen, 2016; Hagenauer et al., 2023). These dispositions influence teachers' orientations toward digital technologies, their willingness to engage in professional development and pedagogical experimentation, the value they attach to such practices, and their persistence when encountering challenges in technology-enhanced teaching. Affective-motivational dispositions are viewed as dynamic, situationally sensitive, and malleable, developing through professional experience, learning opportunities, and interaction with institutional and classroom contexts (Blömeke et al., 2015).

At a descriptive level, the affective-motivational dimension of PDC encompasses teachers' feelings and beliefs related to particular teaching and learning situations (Wessels et al., 2018). In the literature on technology integration, these motivational aspects are often referred to using broad, everyday terms such as **confidence** or **attitudes** towards digital technologies (e.g., Instefjord & Munthe, 2017; Ley et al., 2022). While such terms capture important aspects of teachers' subjective experience, they remain conceptually underspecified and offer limited explanation for understanding why teachers engage with digital pedagogy, how persistently they invest effort, or why similar knowledge resources may lead to different pedagogical choices.

Within the EffectiVe project, these descriptive notions are therefore situated within established motivational theories that allow for a more precise account of the mechanisms underlying teachers' engagement and pedagogical decision-making. In particular, EffectiVe draws on **two complementary motivational perspectives**, namely **self-efficacy theory** (Bandura 1989; Bandura, 1977) and **expectancy-value theory** (EVT) (Eccles & Wigfield, 2002), which are treated as analytically distinct yet mutually informative in explaining different aspects of teachers' motivational functioning within the PDC framework.

2.2.3. Self-efficacy as a motivational mechanism in PDC

A core affective-motivational disposition within PDC is teachers' self-efficacy. Following Bandura (1989), self-efficacy is defined as competence-, task-, and context-specific beliefs about one's capability to organize and execute actions required to manage prospective situations. Importantly, self-efficacy refers to **perceived capability**, not to actual skill or knowledge. As such, it functions as a motivational mechanism that shapes whether, how, and with what level of effort teachers mobilize their professional resources in concrete situations.

In the context of pedagogical digital competence, self-efficacy does not directly equate to teachers' actual ability to integrate digital technologies. Rather, it influences teachers' willingness to engage with instructional challenges, their persistence when difficulties arise, and their strategic regulation of effort and action in technology-enriched teaching contexts (Lazarides & Warner, 2020; Wang et al., 2004). Through these mechanisms, self-efficacy operates as an enabling condition for the enactment of cognitive and pedagogical resources in practice.

Within the EffectiVe project, we focused on two domain-specific, context-sensitive forms of self-efficacy: **self-efficacy to implement SRL** (De Smul et al., 2018) and **self-efficacy for digital teaching** (van Acker et al., 2013). **Self-efficacy to implement SRL** refers to teachers' beliefs about their capability to support, scaffold, and promote students' self-regulated learning processes through instructional design, guidance, and feedback (Dignath-van Ewijk, 2016). This form of self-efficacy is particularly relevant in technology-enriched learning environments, where students are often required to plan, monitor, and evaluate their learning more independently and where teachers play a key role in creating structures that make these processes visible and supported. **Self-efficacy for digital teaching**, in turn, reflects teachers' confidence in their ability to use digital learning tools successfully and effectively in their teaching (van Acker et al., 2013). As such, it represents an important affective-motivational condition that influences whether and how teachers engage with digital technologies in their teaching.

Empirical studies suggest that teachers' self-efficacy is related to several important outcomes at both teacher and student levels (De Smul et al., 2018). First, self-efficacy is linked to teachers' emotional experiences and well-being, including job satisfaction (Skaalvik & Skaalvik, 2010). Second, it is associated with teachers' intentions to participate in professional development and to adopt innovative teaching practices (Bandura, 1997; De Smul et al., 2018; Skaalvik & Skaalvik, 2007). Finally, previous research and large-scale international studies indicate that teachers' self-efficacy beliefs may also be related to student learning processes and outcomes, including their self-regulated learning (OECD, 2025b; Skaalvik & Skaalvik, 2007).

2.2.4. Attitudes, value, and cost: an expectancy–value perspective

Closely related to self-efficacy beliefs are teachers' **attitudes** towards digital technologies and their **confidence** in using them in classroom practice. Attitudes can be understood as evaluative orientations toward a particular object or situation, grounded in teachers' beliefs about the usefulness, relevance, and consequences of technology use in education (Instefjord & Munthe, 2017). Empirical research shows that teachers' attitudes and confidence are associated with whether and how digital tools are used in practice, and that teachers who already apply digital tools in teaching are often more motivated to extend their use and further develop their skills (Ertmer et al., 2012; Pongsakdi et al., 2021). Whereas self-efficacy concerns teachers' beliefs about whether they can act effectively, expectancy–value theory helps explain whether they see such action as worthwhile and sustainable.

Within EffectiVe, these attitudinal orientations are further theorized using **expectancy–value theory** (Eccles & Wigfield, 2002), which provides a framework for understanding how perceived success, subjective value, and anticipated costs shape engagement, persistence, and pedagogical choices. From an EVT perspective, teachers' attitudes towards digital pedagogy reflect underlying value-related appraisals (e.g., perceived importance, usefulness, or intrinsic interest of digital pedagogy) as well as perceived costs associated with engagement, such as effort, time investment, or emotional strain (Osman & Warner, 2020; Ranellucci et al., 2020).

Applied to teachers' professional development and digital pedagogy, EVT helps explain why teachers may differ in their engagement with technology-enhanced teaching and with pedagogical approaches that promote SRL. Teachers who expect to be successful in integrating digital tools, who perceive digital pedagogy as meaningful for student learning, and who experience the associated costs as manageable are more likely to engage actively in professional learning, experiment with new instructional practices, and persist when challenges arise. Conversely, low perceived value or high perceived costs may

constrain teachers' motivation to invest in the development of pedagogical digital competence, even when relevant knowledge and skills are available.

EffectiVe novelty: strengthening the role of motivational beliefs in professional development and enacted practice

A key contribution of the EffectiVe project is the **explicit integration of teachers' motivational beliefs into the conceptualization of PDC**. While many existing frameworks focus primarily on teachers' knowledge and skills, EffectiVe highlights that teachers' motivation plays a crucial role in whether and how digital pedagogy is implemented in practice.

Drawing on **self-efficacy theory** and **expectancy-value theory**, EffectiVe incorporates motivational dimensions such as teachers' beliefs about their capability to use digital pedagogy, the perceived value of technology for learning, and the effort or demands associated with implementing digital practices.

Importantly, **EffectiVe links teachers' motivation not only to their pedagogical practice but also to their own professional learning processes**. Teachers' motivational beliefs influence how they engage with professional development, how persistently they experiment with new digital practices, and how they adapt their teaching over time.

At the same time, the project highlights that **teachers' motivation and pedagogical digital competence shape how teachers support students' self-regulated learning (SRL) in technology-rich classrooms**. In this way, EffectiVe connects teachers' professional learning, motivational beliefs, and classroom practice within a single framework (De Smul et al., 2019; Dignath, 2021; Hirt et al., 2022).

Overall, the project shows that strengthening teachers' pedagogical digital competence requires attention not only to knowledge and skills, but also to the motivational beliefs that influence whether teachers adopt, sustain, and refine digital pedagogical practices.

2.2.5. Situation-specific skills bridging dispositions and performance

Situation-specific professional skills constitute a core component of Pedagogical Digital Competence (PDC) and refer to teachers' capacity to respond effectively to the complex and dynamic demands of classroom situations, particularly in technology-enhanced learning environments. This level captures teachers' ability to notice, interpret, and respond to relevant features of instructional situations as they unfold in real time (Blömeke et al., 2015;

Stahnke & Blömeke, 2021). In contrast to general knowledge or dispositional characteristics, situation-specific skills are inherently contextual. They emerge when teachers apply their knowledge, beliefs, and experiences to interpret what is happening in a specific teaching situation and decide how to respond.

The cognitive and affective-motivational dispositions discussed in the previous sections, together with teachers' self-regulated learning (SRL) skills related to planning, monitoring, and adaptation, form the **underlying enabling conditions** for the development and enactment of situation-specific skills (Blömeke et al., 2015; Hirt et al., 2022; Karlen et al., 2020; Winne, 2018). These resources shape how teachers attend to classroom events, make sense of instructional challenges, and regulate their responses to situational demands over time. Teachers' SRL skills are particularly important for translating professional learning into adaptive action, for example, by planning pedagogically meaningful technology integration, monitoring students' engagement and learning processes as they unfold, and adjusting instructional support in response to emerging needs.

At the core of situation-specific skills are the interrelated processes of **perception, interpretation, and decision-making**, which are central to process-oriented models of teacher competence (see e.g. Blömeke et al., 2015; Stahnke & Blömeke, 2021). These processes enable teachers to transform available information from instructional situations into pedagogically meaningful action. **Perception** involves the selective noticing of relevant cues in a teaching situation, such as students' engagement, understanding, or emotional states. **Interpretation** refers to analysing and integrating this information in order to understand its pedagogical significance. **Decision-making** then entails selecting and enacting appropriate instructional actions based on this understanding (Blömeke et al., 2015). The three cognitive processes are not sequential, but **tightly interwoven, unfold rapidly and may call for regulation** during instruction. Their role becomes particularly salient in technology-enhanced classrooms, where multiple information sources and interactional dynamics must be coordinated simultaneously and where teachers need to respond to rapidly changing instructional conditions. Accordingly, situation-specific skills enable teachers to adapt their pedagogy to situational demands, rather than relying on predefined strategies or routines.

Empirical research indicates that situation-specific skills are strong predictors of teachers' instructional behaviour and instructional quality (Stahnke & Blömeke, 2021). For instance, studies in the domain of classroom management have shown that teachers' abilities to perceive and interpret classroom situations are more closely related to their actions than theoretical knowledge alone (Müller & Gold, 2026). This underscores the importance of examining competence as a **continuous process of transferring and activating knowledge**

and dispositions into instructional action across situations, rather than focusing exclusively on conceptual knowledge or subjective beliefs.

In the context of the EffectiVe project, situation-specific professional skills are particularly relevant for understanding how teachers integrate digital tools into pedagogical practice. When planning lessons or designing technology-enhanced learning activities, skillful enactment of these skills involves teachers' capacity to anticipate possible classroom scenarios, foresee students' learning and regulation challenges, and identify appropriate courses of action. During instruction, these skills are reflected in teachers' ability to monitor how students engage with digital tools, interpret indicators of understanding or difficulty, and make timely decisions about instructional support, scaffolding, or adaptation. Thus, situation-specific skills function as the mediators between dispositions and practice, enabling teachers to translate cognitive and affective-motivational resources into responsive and context-sensitive pedagogical action (Kasepalu et al., 2024; Müller & Gold, 2026; Stahnke & Blömeke, 2021).

2.2.6. Teachers' performance and practice as enacted dispositions and skills

The performance or practice level of PDC refers to teachers' situated pedagogical enactment, where cognitive and affective-motivational dispositions and situation-specific skills are brought together in responsive instructional action. At this level, PDC becomes observable through teachers' **planning, implementation, and evaluation of teaching**, reflecting how professional resources are activated and coordinated in concrete classroom situations (Hall & Smith, 2006; Roth et al., 2023). Performance thus captures how teachers translate their professional knowledge, beliefs, and skills into pedagogical action in technology-enhanced learning environments.

Teachers demonstrate their PDC in practice by planning and delivering instruction that aligns with their pedagogical intentions (Hall & Smith, 2006) and by using digital tools in ways that are **flexible, purposeful, and adaptive** to classroom realities and situational variation. This includes recognizing and responding to students' cognitive, motivational, and regulatory needs as they emerge; providing timely and targeted co-regulatory support; modelling effective learning strategies within instruction; and fostering inclusive and supportive learning environments. In technology-enhanced settings, such enactment requires teachers to continuously monitor students' engagement and learning processes, interpret indicators of progress or difficulty, and adjust instructional support accordingly.

Importantly, performance is a **dynamic and cyclical interface** where dispositions and skills are repeatedly enacted, refined, and transformed through experience (Hall & Smith, 2006; Kang, 2016). The practice level, therefore, reflects teachers' capacity to translate planning

into action and to make informed, real-time instructional decisions that integrate digital technologies meaningfully in support of students' autonomy, engagement, and learning. Through this ongoing enactment, teachers' PDC is both expressed and further developed, reinforcing the dynamic and process-oriented understanding of pedagogical digital competence that underpins the EffectiVe framework.

2.3 Self-regulated learning as a cross-cutting theoretical and practical lens in PDC development

EffectiVe novelty: Teachers' SRL skills as a cross-cutting lens in PDC development

EffectiVe **conceptualizes teachers' SRL as a core mechanism in the development of PDC.** Teachers' ability to plan, monitor, evaluate, and adapt connects their pedagogical knowledge, motivation, and skills to pedagogical decision-making and classroom practice. This makes it possible to view PDC development as a coherent and developmental learning trajectory. The following section therefore conceptualizes SRL as a cross-cutting lens that supports the development, integration, and enactment of PDC across dispositions, situation-specific skills, and practice.

2.3.1. Theoretical conceptualization of self-regulated learning

Self-regulation refers to the processes through which individuals actively manage their thoughts, emotions, motivation, and actions in the pursuit of personally meaningful goals (Zimmerman, 2000). Building on this definition, **self-regulated learning (SRL) is understood as a multi-component, iterative process through which learners plan, monitor, and adapt their learning-related activities in response to task demands, feedback, and changing conditions** (Boekaerts, 2002; Boekaerts & Cascallar, 2006). Importantly, SRL operates at a **meta-level** by regulating the cognitive, motivational, emotional and behavioural processes through which learning occurs, thereby enabling, sustaining, and optimising learning over time.

From this perspective, SRL provides a framework for understanding how learners manage their engagement with learning tasks. Learning outcomes depend on cognitive processing of content, whereas SRL concerns how learners set goals, allocate effort, select strategies, monitor progress, and regulate motivation and emotion in order to support effective learning. This distinction is critical, as it underscores that strong regulatory skills do not replace instruction or learning processes, but support their effectiveness under varying conditions.

A range of complementary theoretical models has been developed to describe how self-regulatory processes unfold over time and across contexts (for a detailed overview, see Panadero, 2017). Zimmerman's (2000) cyclical model conceptualizes SRL as a recursive

cycle comprising phases of forethought, performance, and self-reflection, through which learners continuously adjust their strategies based on internal and external feedback. Pintrich's (2000) model similarly structures SRL into phases of forethought, monitoring, control, and reflection across multiple areas of regulation, including cognition, motivation and affect, behaviour, and context. Winne and Hadwin (1998) emphasize metacognitive monitoring as a central mechanism in SRL, framing regulation as a feedback-driven process involving task definition, goal setting, enactment, and adaptation.

From a motivational–emotional perspective, Boekaerts' **Dual Processing Model** (2011) highlights that regulation serves both learning and well-being functions. They show that learners may shift between mastery-oriented and well-being-oriented pathways depending on situational appraisals, while Efklides' **Metacognitive and Affective Model of SRL** (2011) distinguishes between more stable person-level regulation and situational task × person regulation. These perspectives are particularly relevant for EffectiVe because they help explain how regulatory processes are shaped by both relatively stable dispositions and immediate classroom demands.

Motivational beliefs play a central role in these regulatory processes. From an expectancy–value perspective, learners' engagement in learning activities depends on their beliefs about expected success, the subjective value they attach to the task, and the perceived costs associated with engagement, such as effort, time investment, or emotional strain (Barron & Hulleman, 2015; Eccles & Wigfield, 2002). These motivational appraisals are closely intertwined with SRL processes, as they shape goal setting, persistence, effort regulation, and strategic adaptation over time (Pintrich, 2000; Boekaerts, 2011). SRL provides the process-level mechanisms through which expectancy, value, and cost beliefs are enacted and dynamically adjusted in learning situations.

Within SRL processes, self-efficacy shapes learners' beliefs about their capacity to meet task demands and regulate their learning effectively (Bandura, 1989). It influences how confidently learners approach challenging tasks, how persistently they invest effort, and how strategically they engage in planning, monitoring, and adaptation. Stronger self-efficacy has been associated with greater persistence, effort regulation, and strategic control, particularly under conditions of difficulty or uncertainty (Holden & Rada, 2011).

Within ongoing self-regulatory processes, self-efficacy interacts closely with value appraisals and perceived costs, thereby linking motivational engagement with cognitive demands. Learners with higher self-efficacy are more likely to perceive demanding tasks as manageable, to allocate cognitive resources more strategically, and to sustain regulatory effort despite increased cognitive load. In this way, self-efficacy functions as a key

motivational mechanism through which expectancy-related beliefs shape learners' regulation of cognition, effort, and emotion in response to task complexity.

The interaction between self-regulation and learning is further shaped by cognitive demands, as described in **Cognitive Load Theory** (CLT) (Sweller, 1988; Sweller, van Merriënboer, & Paas, 2019). Excessive intrinsic or extraneous cognitive load can increase perceived costs and undermine regulatory engagement, whereas well-designed learning environments can support germane processing, foster a sense of competence, and facilitate effective self-regulation (Seufert, 2018). Through SRL processes, learners actively manage cognitive resources by selecting strategies, allocating effort, and monitoring understanding in order to balance cognitive demands and sustain motivation.

More recently, SRL has been extended beyond the individual learner to include socially shared regulation of learning (SSRL), which emphasizes how regulatory processes can be distributed and co-constructed through collaborative interaction (Hadwin, Järvelä, & Miller, 2017). From this perspective, regulation emerges through shared planning, monitoring, and adaptation, highlighting the social and contextual embeddedness of regulatory processes in collaborative learning environments.

2.3.2. Self-regulated learning as a cross-cutting mechanism

Taken together, SRL provides a strong theoretical basis for understanding how learners regulate their engagement with learning activities in pursuit of learning goals (Pintrich, 2000; Zimmerman, 2000). In EffectiVe, **SRL is conceptualized across three interconnected layers: (1) teachers' conceptual understanding of regulation, (2) teachers' own regulatory skills in professional learning and instructional work, and (3) the pedagogical enactment of SRL support** in classrooms.

At the level of dispositions, SRL is reflected in teachers' conceptual understanding of regulation, including knowledge about goal setting, strategic learning, monitoring, and reflection, as well as awareness of how motivation, emotion, and contextual factors shape learning and teaching processes. This includes teachers' pedagogical understanding of how self-regulated learning develops across age groups, how different instructional and technological features may support or hinder regulation, and how regulatory demands vary across learning situations (Karlen et al., 2020). Such knowledge forms an essential foundation for recognizing when and how regulatory support is needed in instructional practice. At the level of professional learning and practice, SRL also refers to teachers' own regulatory skills as learners and professionals (Karlen et al., 2020; Hirt et al., 2022; Hirt et al., 2025).

Teachers are themselves required to engage in continuous learning, adapt to evolving pedagogical and technological demands, and regulate their engagement with complex

instructional challenges. From this perspective, teachers' ability to plan, monitor, and adapt their professional learning and instructional practices is a prerequisite for the development and enactment of pedagogical digital competence. Self-regulation enables teachers to manage cognitive load, sustain motivation, and persist in the face of uncertainty and change, all conditions that are particularly salient in digitalized educational contexts.

Crucially, **SRL is also enacted pedagogically through teachers' instructional decisions and interactions with students.** Within EffectiVe, teachers are viewed not only as self-regulated learners but also as **designers and facilitators** of learning environments that make regulatory processes visible and accessible to students. This involves the capacity to embed regulatory support into pedagogical design, to scaffold planning, monitoring, and reflection during instruction, and to diagnose and respond to students' regulatory challenges in situ. Importantly, such support may be provided explicitly or implicitly, depending on learners' age, prior experience, and situational demands, and must be balanced with the primary goal of supporting learning at that moment.

By conceptualizing SRL across these interconnected layers (i.e conceptual knowledge about regulation, teachers' own regulatory skills, and pedagogical enactment in classrooms), **EffectiVe highlights SRL as the mechanism that links teachers' dispositions, situation-specific skills, and performance.** This integrated perspective helps explain why pedagogical digital competence cannot be reduced to knowledge of tools or instructional strategies alone. Instead, PDC development depends on teachers' capacity to regulate learning processes over time, to adapt pedagogical action to situational demands, and to support students' learning in ways that foster both immediate understanding and the long-term development of self-regulated learning skills.

In this way, SRL underpins EffectiVe's view of PDC as a dynamic, developmental, and context-sensitive competence. EffectiVe emphasizes that self-regulation enables learning by coordinating cognitive, motivational, and emotional processes in response to task demands and instructional goals. Positioning SRL as a cross-cutting lens thus provides a coherent theoretical foundation for understanding how pedagogical digital competence is developed, enacted, and sustained in complex, technology-mediated learning environments.

3. From knowledge to practice: A competence framework and training-to-impact pathway in EffectiVe

3.1 Competence development as a process from dispositions to practice

Building on the conceptualization presented in Chapter 2, **EffectiVe understands PDC as a process through which teachers' internal resources are translated into adaptive teaching practice**. In this view, competence is expressed through how teachers mobilize and regulate their resources in authentic pedagogical situations.

The competence development model assumes that cognitive dispositions, affective-motivational dispositions, and teachers' own SRL skills jointly support the emergence of situation-specific skills. In EffectiVe, these skills refer primarily to teachers' ability to perceive relevant classroom events, interpret them in pedagogically meaningful ways, and make informed instructional decisions. Such abilities are especially important in technology-enhanced learning environments, where teachers must continuously balance pedagogical goals, technological affordances, students' learning needs, and contextual constraints.

Figure 2 synthesizes this competence development process by showing **how internal dispositions are progressively transformed into observable teaching practices**. It illustrates how cognitive and affective-motivational resources, together with teachers' own SRL skills, shape situation-specific processes of perception, interpretation, and decision-making. These processes enable teachers to respond adaptively to classroom demands and to design learning environments that support students' self-regulated learning and deeper learning with technology. The framework also highlights **motivational adoption intentions**, such as expectancy, value, and perceived cost, **as a mediating mechanism** linking situation-specific skills to enacted practice. The process culminates in observable teaching behaviour, including the design and enactment of cognitively activating, SRL-supportive, and pedagogically meaningful learning experiences.

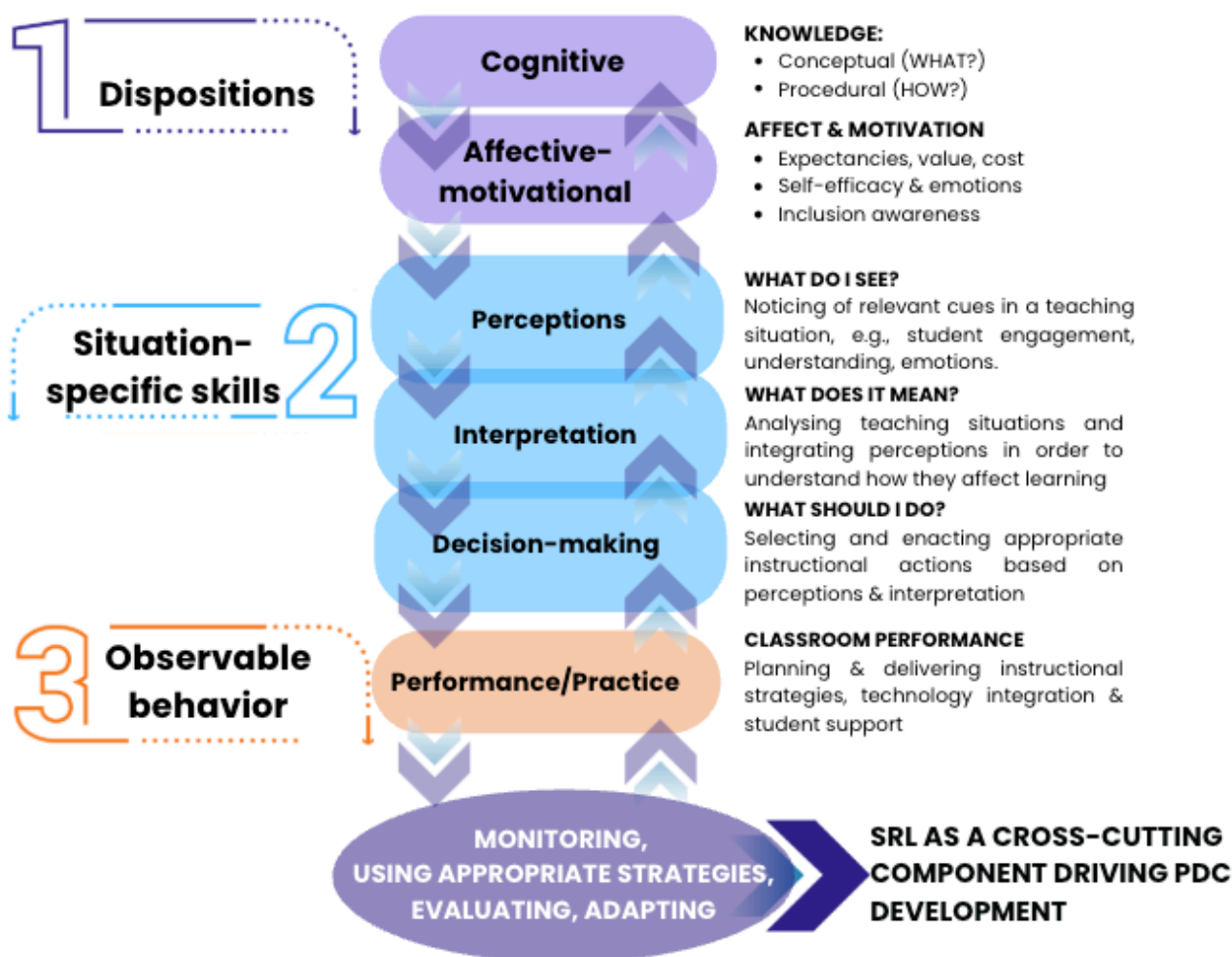


Figure 2: Competence Development model built on Blömeke et al. (2015).

Importantly, enacted practice is not the endpoint of competence development. Rather, practice feeds back into the process through self-regulatory activities such as monitoring, evaluation, strategy use, and adaptation. Through reflection on instructional outcomes, student responses, and their own teaching experiences, teachers refine their strategies and gradually reshape their cognitive and affective-motivational dispositions. In this way, SRL functions as a recursive mechanism that connects practice back to dispositions and enables continuous competence development over time.

The next section extends this competence development perspective into a broader project-level training-to-impact pathway that links teacher learning to the intervention logic and empirical design of EffectiVe.

3.2 Training-to-impact pathway and analytical logic of the project

Building on the competence development perspective outlined in Section 3.1, EffectiVe adopts a broader **training-to-impact pathway** that operationalises this conceptual model at project level. While the competence development model (see Figure 2) explains how teachers' dispositions are transformed into situation-specific skills and enacted practice, the project also requires an analytical framework that situates this developmental process within training design, implementation, and outcome evaluation across diverse national cases. The purpose of this pathway is therefore not to replace the competence model, but to translate it into a shared intervention and analytical logic that can guide the empirical work of the project.

Within this framework, **training is conceptualised as an intervention that activates and develops teachers' cognitive dispositions, affective-motivational dispositions, and self-regulatory capacities.** These internal resources are expected to support the development of situation-specific skills, particularly teachers' ability to perceive, interpret, and respond to classroom situations, and their gradual translation into enacted teaching practice. At the same time, the pathway makes visible the broader conditions through which this development is expected to occur, including teacher preconditions, training design, training processes and experiences, and contextual moderators.

EffectiVe operationalises training through **four complementary methods:** Knowledge Instruction, Collaborative Design, Situated Learning, and Mentoring/Coaching. These methods are not treated as fixed formats, but as design principles that can be combined and adapted across contexts. Together with broader parameters such as duration, intensity, delivery mode, and degree of support, they constitute the intervention input of the model (see also Seufert et al., 2024).

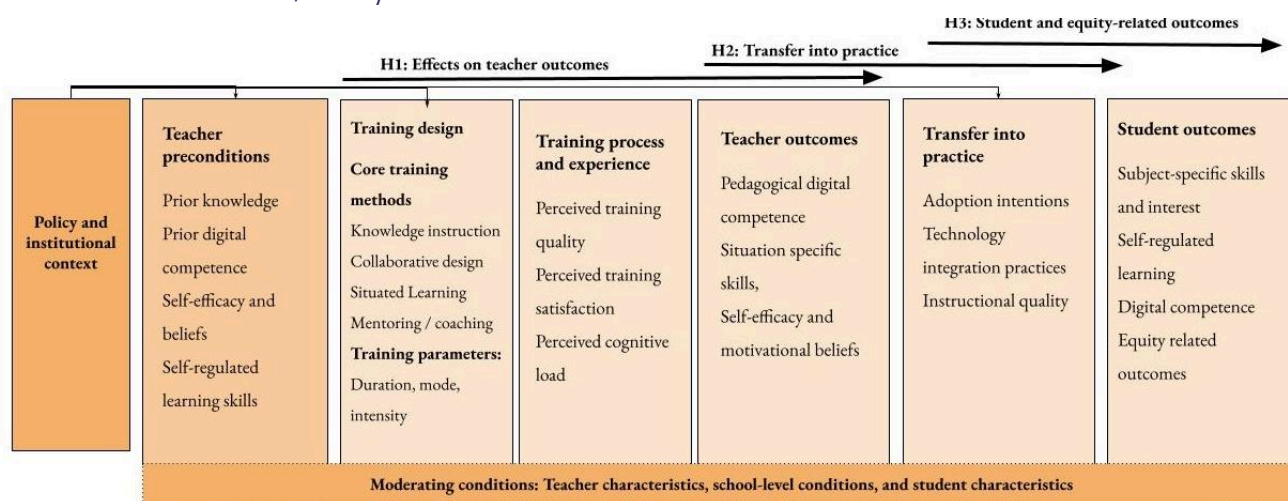


Figure 3: EffectiVe training-to-impact pathway and analytical logic

Figure 3 summarises the project's training-to-impact pathway and analytical logic. It operationalises the competence development model presented in Section 3.1 by situating teachers' competence development within a broader intervention and evaluation framework. Importantly, the pathway is embedded in policy and institutional conditions, which shape teacher preconditions, influence the design and implementation of professional development, and affect the transfer and sustainability of pedagogical change. Within this framework, training design and teacher preconditions are expected to shape teachers' training processes and experiences, which in turn contribute to proximal teacher outcomes, support transfer into practice, and ultimately relate to student and equity-related outcomes.

Within this pathway, teacher preconditions and training design are expected to shape teachers' training processes and experiences, such as perceived quality, satisfaction, cognitive load, and engagement. These learning processes are expected to contribute to proximal teacher outcomes, which in turn support transfer into practice through adoption intentions, technology-integration practices, and the design of cognitively activating and self-regulated learning-supportive learning environments. Stronger transfer into practice is expected to relate to student and equity-related outcomes.

Importantly, in *EffectiVe*, teacher professional development is not understood as an isolated intervention, but as a process embedded in broader policy and institutional conditions. As shown in D1.1, the partner countries differ in educational governance, digital education strategies, the formal status of pedagogical digital competence, and the ways in which self-regulated learning, equity, and digital competence are addressed in policy and practice. These system-level conditions shape both teachers' preconditions and the design, implementation, and sustainability of professional development. The training-to-impact pathway should therefore be interpreted as situated within a wider policy and institutional context that enables, constrains, and gives direction to teacher PDC development.

At the same time, the pathway serves a methodological function in the project. It provides the shared analytical backbone for the empirical work in WP2 and WP3 and supports alignment across the case-based studies and the cross-case synthesis. The pathway offers a common structure for positioning case-level findings: studies may focus on training processes and participant reactions, proximal teacher outcomes, transfer into practice, or student and equity-related outcomes, depending on their design, measures, and implementation context. In this way, the pathway enables methodological diversity across national cases while maintaining conceptual coherence at project level.

3.3 How training methods support dispositions, skills, and practice

In EffectiVe, the four training methods are conceptualized as complementary mechanisms that support different dimensions of PDC development (Seufert et al., 2024)

- **Knowledge Instruction** primarily supports cognitive dispositions by developing teachers' conceptual and procedural understanding of pedagogy, technology integration, and self-regulated learning.
- **Collaborative Design** supports both dispositions and situation-specific skills by engaging teachers in joint planning and reflection, fostering the alignment of pedagogical beliefs and practices.
- **Situated Learning** supports the transition from knowledge to practice by embedding learning in authentic teaching contexts, where teachers apply and adapt their skills in real classroom situations.
- **Mentoring and Coaching** support reflection, regulation, and adaptation across all stages of competence development, particularly by strengthening teachers' self-efficacy, motivation, and capacity for ongoing professional learning.

These methods are not intended as isolated components, but as combinable elements within coherent training designs. Their integration enables recursive cycles of planning, enactment, reflection, and adaptation, aligning with EffectiVe's understanding of PDC as a dynamic and self-regulated competence. Although each method is associated with particular strengths, their effects are not exclusive; in practice, all four methods may contribute to multiple dimensions of PDC development.

Beyond their role as instructional formats, the **four training methods can also be understood as activating different learning mechanisms** through which teachers gradually develop deeper pedagogical understanding and transfer it into practice. In this respect, EffectiVe aligns with prior work on knowledge appropriation and the integration of knowledge appropriation, scaffolding, and maturation (KAM) practices into teacher professional development (Ley et al., 2020; Ley et al., 2022). Our earlier research suggests that professional learning is more likely to **support stronger adoption intentions when teachers are supported in progressively integrating new practices into their own pedagogical work** through shared understanding, collaborative design, enactment in authentic practice, and scaffolded reflection (e.g., Ley et al., 2022; Khulbe et al., 2025).

From this perspective, teacher learning is treated beyond the acquisition of knowledge and seen as a gradual process in which conceptual and procedural input is first appropriated, then elaborated and reorganised through social interaction and guided support, and finally matured through enactment, reflection, and adaptation in authentic contexts. This

perspective is particularly relevant in EffectiVe, where the aim is not only to increase teachers' knowledge about digital pedagogy, but to support deeper learning that leads to situation-specific judgment, adaptive expertise, and transferable pedagogical action.

4. From teacher competence to student learning: Evidence on self-regulated learning support in technology-enhanced classrooms

Building on the conceptualization of PDC and the training-to-impact pathway presented in Chapters 2–3, this chapter shifts the focus to the **classroom-level enactment of teacher competence and its relevance for student learning**. In particular, it examines how teaching strategies in technology-enhanced learning environments can support students' SRL, extending the findings of T1.3 where we carried out a literature review of the existing teaching practices for SRL support (see Appendix 1). The purpose of this chapter is not to provide a comprehensive review of SRL-supportive pedagogy, but to illustrate how the EffectiVe conceptualization of PDC becomes visible in classroom design and orchestration in technology-enhanced learning environments.

Within the EffectiVe framework, **supporting SRL is understood as a pedagogical design and orchestration challenge**. Teachers are required to align learning goals, instructional activities, and digital tools in ways that make students' learning processes visible, interpretable, and open to regulation. This process is inherently situated and depends on teachers' ability to translate their cognitive and motivational resources into context-sensitive pedagogical action.

A defining characteristic of SRL-supportive pedagogy is the **intentional structuring of learning processes across regulatory phases** (Boekaerts, 2011; Zimmerman, 2000). Effective learning environments provide opportunities for learners to plan, monitor, and reflect on their learning, while adapting the level of guidance to task demands and learner needs. This includes making goals explicit, embedding prompts and feedback that support monitoring during task execution, and creating space for reflection on both outcomes and learning processes. Importantly, such support may range from explicit instruction of regulatory strategies to more implicit forms embedded in task design and interaction.

From a pedagogical perspective, **SRL is closely linked to cognitively activating and interactive learning designs**. Approaches such as inquiry-based learning, collaboration, feedback-rich tasks, and iterative problem-solving create conditions in which learners are required to regulate their understanding, effort, and strategies. At the same time, these designs require a careful balance between structure and autonomy: insufficient guidance may overwhelm learners, whereas overly structured environments may limit opportunities for independent regulation.

Digital technologies play a **mediating role** in this process by **enabling the externalization and visibility of learning processes**. Tools that provide feedback, capture learning traces, or support collaboration can make aspects of students' thinking and engagement observable

to both learners and teachers. However, within the EffectiVe framework, technology is not treated as a driver of SRL in itself. Rather, its value lies in how it is pedagogically enacted, for example, by supporting feedback, structuring learning sequences, or enabling shared regulation. The value of digital technologies depends on how they are pedagogically enacted, which in turn requires teachers to coordinate pedagogy, content, and technology in context. (From, 2017; Mishra & Koehler, 2006).

A further defining feature of SRL-supportive teaching is the **recognition that regulation is not only individual but also socially embedded**. In collaborative learning contexts, regulatory processes can be shared, negotiated, and co-constructed. Teaching strategies that incorporate peer interaction, joint problem-solving, and collective reflection therefore support both individual and socially shared regulation of learning, which is particularly relevant in digitally mediated environments (Hadwin et al., 2018; Järvenoja et al., 2015; Zabolotna, 2026).

Within this perspective, the **teacher's role is central**. Supporting SRL requires teachers to continuously interpret students' cognitive, motivational, and emotional states and adapt their pedagogical actions accordingly. This includes diagnosing when learners need more structure or more autonomy, deciding when to intervene, and selecting appropriate forms of scaffolding. These processes directly reflect the situation-specific skills described earlier (perception, interpretation, and decision-making) and show how SRL support is enacted through teachers' professional judgment in real time. (Blömeke et al., 2015).

From the perspective of PDC, **effective SRL support emerges from the integration of knowledge, motivation, and situation-specific skills in practice**. Teachers need not only conceptual understanding of SRL and digital pedagogy, but also the motivational readiness to engage with complex instructional challenges and the capacity to adapt their actions to situational demands. In this sense, **SRL functions both as an instructional goal for students and as a mechanism through which teachers regulate their own professional practice**. When these competencies intersect, teachers can design learning environments that scaffold and challenge students' self-regulation, enabling them to manage cognitive load, sustain motivation, and gradually assume greater responsibility for their learning (Seufert, 2018; Järvenoja et al., 2025).

Taken together, SRL-supportive teaching in technology-enhanced environments is characterized by:

- the intentional design of learning processes across regulatory phases;
- the integration of SRL into cognitively activating and interactive pedagogical approaches;

- the pedagogical use of digital tools to make learning processes visible and actionable; and
- the teacher's adaptive orchestration of learning activities in response to students' needs.

These principles provide a conceptual bridge between the competence framework outlined in Chapters 2–3 and the classroom-level enactment of PDC. They also inform the design of EffectiVe training interventions, which aim to strengthen teachers' capacity to embed SRL support systematically into technology-enhanced learning environments.

EffectiVe novelty: SRL-supportive teaching as an enactment of PDC

A key contribution of EffectiVe is the **conceptualization of SRL-supportive teaching as an enactment of PDC in classroom practice.**

Supporting SRL is **understood as a situated process of pedagogical design** and orchestration in which teachers align learning goals, student needs, and technological affordances in real time.

This perspective **foregrounds teachers' situation-specific skills** and highlights the **pedagogical use of digital tools to make learning processes visible** and open to regulation at both individual and collaborative levels.

4.1 Illustrative lesson designs from EffectiVe interventions

To complement the conceptual discussion and illustrate how PDC is enacted in practice, this section presents selected illustrative lesson designs developed by teachers participating in EffectiVe interventions. These lesson designs are not presented as evaluated or standardized models of SRL-supportive teaching. Rather, they provide situated illustrations of how teachers embed and orchestrate SRL processes in technology-enhanced classrooms. As such, they offer insight into how EffectiVe training content and methods are interpreted, adapted, and translated into concrete instructional design and classroom practice.

Example 1: Nature science, primary education

The first illustrative lesson design (Table 1) originates from an intervention implemented by TLU within EffectiVe. It demonstrates how SRL can be explicitly scaffolded in age-appropriate ways in technology-enhanced primary education.

Table 1. TLU – Nature Science (Primary Education) Lesson Design

Context: Primary education (ages 11–12), Natural Science

Focus: Understanding characteristics of living organisms

SRL focus	<ul style="list-style-type: none"> ● Planning: activating prior knowledge ● Monitoring: evaluating understanding during tasks ● Reflection: evaluating learning and emotions ● Shared regulation: pair work and discussion
Pedagogical design	Guided inquiry with structured individual and pair activities supporting concept formation and metacognitive engagement
Digital tools	<ul style="list-style-type: none"> ● H5P (SRL prompts) ● Padlet / Google Slides (concept mapping) ● Mentimeter (prior knowledge activation, reflection)
Teacher orchestration	Structured lesson phases, modelling thinking aloud, metacognitive questioning, and strategic use of digital tools
Making learning visible	<ul style="list-style-type: none"> ● Student responses ● Discussions ● Digital artefacts for externalising thinking and progress

Key insight

SRL can be effectively supported through structured questioning and low-complexity digital tools, making students' thinking visible without increasing cognitive load.

All core SRL phases - planning, monitoring, reflection, and shared regulation—are embedded in the lesson structure. **Planning** is supported through activation of prior knowledge using Mentimeter prompts, helping students identify what they know and what they need to learn. **Monitoring** is scaffolded through teacher-led metacognitive questioning (e.g., “How did you find this?”), encouraging students to evaluate strategies rather than rely on immediate confirmation. **Reflection** is integrated through structured prompts addressing both learning outcomes and emotional experiences, supporting early development of evaluative and affective regulation. **Shared regulation** is fostered through pair work and whole-class discussion, enabling joint meaning-making.

The lesson illustrates **how low-complexity digital tools (H5P, Padlet, Mentimeter) can support SRL without increasing cognitive load**, by making students' thinking visible and open to regulation.

Example 2. Science, elementary and lower secondary education

The second illustrative lesson design (Table 2) originates from a TAU intervention and demonstrates how guided inquiry-based instruction can systematically embed SRL processes in science education.

Table 2. TAU – Science (Elementary and Lower Secondary Education) Lesson Design

Context: Upper elementary (Grades 5–6) / lower secondary (Grades 7–8), Science

Focus: Investigating the needs of plants through simple experiments

SRL focus	<ul style="list-style-type: none"> ● Planning: activating prior knowledge and setting inquiry goals ● Monitoring: tracking observations and understanding during the activity ● Reflection: evaluating learning outcomes and strategies ● Shared regulation: co-constructing knowledge through group discussion
Pedagogical design	Guided inquiry-based learning structured through a digital KWL framework, supporting curiosity, metacognitive awareness, and ownership of learning
Digital tools	<ul style="list-style-type: none"> ● Digital KWL templates (e.g., Google Docs, Forms, Padlet) ● Digital observation logs
Teacher orchestration	Introduction of inquiry questions, modelling use of KWL framework, structured transitions between individual, group, and whole-class activities, and targeted prompting during experimentation
Making learning visible	<ul style="list-style-type: none"> ● Completed KWL charts ● Observation logs ● Group discussions and shared conclusions ● Individual reflections

Key insight

Inquiry-based pedagogy combined with simple digital tools can systematically support SRL across all phases, particularly when planning and reflection are explicitly scaffolded.

The lesson systematically integrates all SRL phases through a digital KWL framework. **Planning** is supported through activation of prior knowledge and formulation of inquiry questions. **Monitoring** is embedded through observation logs and group comparison of results. **Reflection** is guided through prompts addressing both outcomes and strategies, while shared regulation emerges through collaborative experimentation and discussion.

Digital tools (e.g., shared documents and observation logs) support the visibility of regulatory processes without increasing technological complexity. The example demonstrates **how PDC is enacted through the alignment of inquiry-based pedagogy, SRL scaffolding, and low-threshold digital tools.**

Example 3: Vocational education context

The third illustrative lesson design (Table X, appendix x) originates from a UULM intervention and illustrates how SRL can be embedded in a practice-oriented and professionally authentic context, primarily through implicit support.

Table 3. UULM – Vocational Education (Bakery Sales Context)

Context: Vocational education (bakery sales assistants), mixed-age group

Focus: Marketing objectives and concepts in a real-world professional context

SRL focus

- **Planning:** setting and understanding learning objectives
- **Monitoring:** implicitly supported through task progression
- **Reflection:** evaluating outcomes and transfer to workplace
- **Shared regulation:** collaboration through presentations and group discussion

Pedagogical design

Structured, practice-oriented instruction in a vocational context, combining authentic workplace-related tasks, collaborative discussion, and reflective transfer activities.

Digital tools

- Digital observation logs
- Digital whiteboard
- Mobile devices (documentation and evaluation)

	<ul style="list-style-type: none"> • Digital survey tools
Teacher orchestration	Structured lesson phases, predefined learning goals, guided discussions, and iterative reflection linked to professional practice
Making learning visible	<ul style="list-style-type: none"> • Whiteboard summaries • Digital documentation (photos, notes) • Group presentations and discussions

Key insight

SRL can be embedded in vocational education through authentic tasks and structured reflection, even when support is implicit rather than explicitly scaffolded

SRL support is most visible in **planning and reflection phases**. Learning objectives are introduced at the outset and aligned with authentic tasks, supporting learners' orientation. Reflection is embedded through discussion and transfer tasks linking learning to workplace practice. **Monitoring** is less explicitly scaffolded, reflecting a common pattern in which SRL is supported indirectly. However, shared regulation emerges through collaborative activities such as joint presentations and group discussions.

Digital tools function as supports for documentation and reflection, rather than as primary instructional drivers. The example illustrates **how teachers orchestrate SRL through structured guidance and authentic tasks** in everyday classroom practice.

4.2. Embedding self-regulated learning across contexts

Taken together, the illustrative lesson designs show how teachers enact PDC across diverse contexts. In line with the EffectiVe framework, PDC is expressed not through specific tools, but through situation-specific design and orchestration decisions that activate, scaffold, or fade SRL processes.

The examples also reflect a broader pattern: **SRL is often supported implicitly within pedagogical designs, with stronger emphasis on performance and reflection than on forethought and monitoring** (Dignath & Veenman, 2021), as also indicated in the evidence synthesis presented in Appendix 1. At the same time, they demonstrate that explicit SRL scaffolding can be integrated through structured prompts, inquiry frameworks, and reflective activities.

Across contexts, PDC becomes visible in teachers' ability to align learning goals, SRL processes, and digital tools in ways that make students' activity observable and open to

regulation, reflecting the role of teachers' situation-specific decision-making in classroom practice (Blömeke et al., 2015). These illustrations therefore provide a concrete link between the conceptual framework (Chapters 2–3) and classroom-level enactment of SRL-supportive teaching. Our examples illustrate how the EffectiVe conceptualization of PDC becomes visible across diverse classroom contexts through teachers' situation-specific design and orchestration decisions.

5. Lessons learned and policy pathways

This deliverable has presented pedagogical digital competence (PDC) as a dynamic, process-oriented construct that integrates cognitive and affective-motivational dispositions, situation-specific skills, and enacted teaching practice, with self-regulated learning (SRL) operating as a cross-cutting mechanism throughout. The conceptual framework, the training-to-impact pathway, the evidence synthesis, and the illustrative lesson designs together point to **several lessons that extend beyond the immediate project context**. This final chapter synthesizes those lessons and identifies policy pathways for teacher education and professional development at national and European levels.

5.1 Key lessons emerging from the conceptual and empirical work

The lessons below should be understood as cross-cutting insights emerging from the combined conceptual work, the evidence synthesis, and the illustrative project cases presented in this deliverable. They do not all rest on the same type or strength of evidence, but together they point to recurring patterns that are relevant for the design and interpretation of teacher professional development for pedagogical digital competence.

PDC development requires integrated training designs.

A central lesson from EffectiVe is that effective technology integration cannot be reduced to the acquisition of technical knowledge or isolated digital skills. Rather, it depends on the interplay between teachers' knowledge, motivation, self-efficacy, situation-specific skills, and professional practice. The lessons above should be understood as cross-cutting insights emerging from the combined conceptual work, the evidence synthesis, the illustrative project cases presented in this deliverable and results from the projects reported in (ref to D3.2, which is in the progress). They do not all rest on the same type or strength of evidence, but together they indicate recurring patterns that are relevant for the design and interpretation of teacher professional development for pedagogical digital competence.

Motivational dispositions shape whether competence translates into practice.

A second recurring pattern concerns the role of motivational dispositions in shaping teachers' engagement with professional development and their willingness to translate new competences into practice. Across the project's conceptual and empirical work, **self-efficacy, expectancy, and task value** repeatedly emerge as relevant factors for how teachers engage with training and whether they persist in implementing new practices. Conversely, high perceived costs, such as time pressure, workload, or emotional strain, may limit implementation even when knowledge and tools are available. This suggests that training design alone is not sufficient: broader policy conditions, including workload

structures and professional recognition, also shape whether competence development is translated into pedagogical change.

SRL needs to be addressed at both teacher and student levels.

The combined conceptual and empirical work also suggests that SRL should not be treated solely as a student-level outcome. Teachers' own self-regulatory capacities, their ability to plan, monitor, evaluate, and adapt their learning and instructional practices, are a prerequisite for designing learning environments that support students' regulation. At the same time, the evidence synthesis indicates that most technology-enhanced interventions support student SRL only indirectly and place limited emphasis on forethought processes such as planning and goal setting. This points to the need for teacher education and professional development to address SRL explicitly at both levels: as a competence teachers need for their own professional learning, and as a pedagogical capacity they enact in classrooms.

Context sensitivity is essential for scalable training models.

The illustrative lesson designs and cross-case comparisons suggest that there is no single pathway for embedding SRL-supportive PDC in practice. Effective training models must be sufficiently structured to ensure quality and coherence, while also remaining flexible enough to adapt to differences in national systems, teacher profiles, school cultures, and classroom realities. Scalability therefore should not be understood as standardization alone, but as the ability to maintain conceptual integrity across diverse implementation contexts.

5.2 Policy pathways

The policy pathways below build also on the cross-country policy and system-level analysis developed in D1.1 (Zabolotna et al, 2024). That earlier work showed that partner countries differ in educational governance, policy instruments, teacher autonomy, support structures, and the formal positioning of pedagogical digital competence, self-regulated learning, and inclusion. The implications below should therefore be understood as cross-cutting and evidence-informed directions that need to be interpreted in relation to national and institutional contexts, rather than as uniform recommendations for all systems.

For national and regional policy authorities.

Teacher education standards and qualification frameworks should recognize PDC as a multidimensional competence that includes pedagogical reasoning, motivational readiness, and self-regulation, rather than focusing narrowly on digital tool use. In contexts where PDC is not yet systematically embedded in initial teacher education, an integrated and mandatory component that combines conceptual foundations with situated practice would

be a valuable step. For continuing professional development, incentive structures should reflect the motivational evidence emerging from the project: accreditation, career progression, and workload arrangements that recognize the demands of meaningful PDC development are likely to be more effective than short-term incentives alone. In addition, quality assurance should move beyond participation rates and satisfaction indicators toward measures that capture competence development and changes in teaching practice.

For teacher education and professional development providers.

Training programmes should be designed in line with the integrated instructional logic outlined in Chapter 3, combining conceptual input, collaborative design, situated experimentation, and reflective support. The findings suggest that teachers engage most strongly when training is closely connected to authentic teaching contexts and provides opportunities to test, adapt, and reflect on new practices. SRL should be embedded as an explicit training objective in two ways: as a competence teachers develop for their own professional learning, and as a pedagogical capacity they are expected to support in students.

For schools and school leaders.

The project also highlights the importance of school-level conditions for the transfer of professional learning into practice. Schools benefit when internal capacity for PDC development is strengthened, for example through in-house trainers, peer support structures, or school-based situated learning. Teachers who have completed PDC-focused training can act as multipliers, provided that they are given time, institutional backing, and alignment with broader school development goals. School leaders are therefore central actors in creating the organizational conditions under which teacher motivation can be sustained and newly developed practices can be implemented.

For European policy and research agendas.

EffectiVe contributes to a growing evidence base showing that teacher competence for digital education cannot be reduced to technology adoption alone. European frameworks such as DigCompEdu could benefit from continuing to evolve toward a more process-oriented understanding of PDC, one that integrates pedagogical judgment, motivation, and self-regulation. In addition, cross-country comparative research on the effectiveness and cost-efficiency of different training designs would support more evidence-informed policy development across Member States.

Taken together, these policy pathways reflect the project's commitment to translating conceptual and empirical insights into actionable guidance. They point to the conditions

under which teachers' pedagogical digital competence is most likely to develop, be sustained, and contribute meaningfully to teaching practice, students' digital competence, subject-specific learning, and self-regulated learning.

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