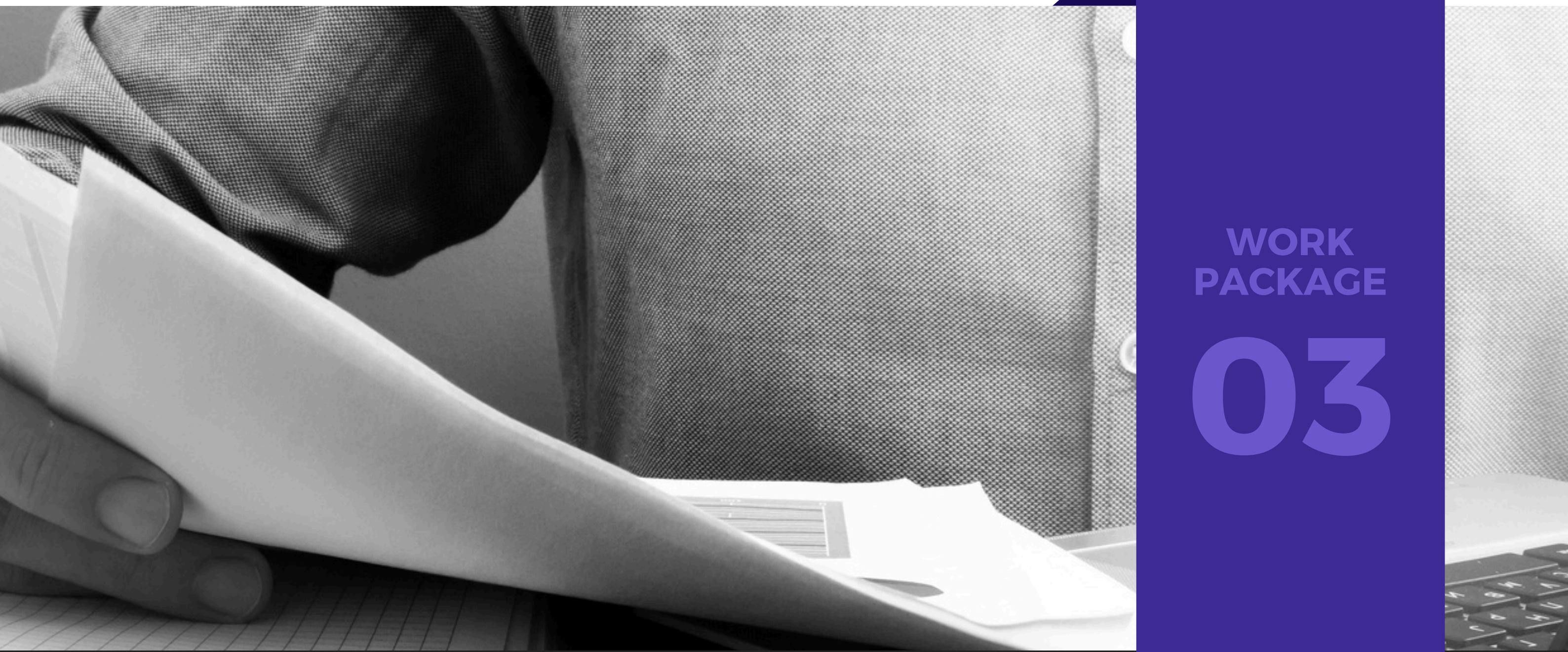

WORK PACKAGE

03

RESEARCH DESIGNS AND INSTRUMENTS FOR DATA COLLECTION

DELIVERABLE D3.1

Work Package 3

Evaluating and Analysing Effectiveness of Teacher Training

Deliverable D3.1

Research designs and instruments for data collection

Delivery date: 30.11.2024

Dissemination level: Public

Lead Beneficiary: UWK

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Project information

Grant agreement number	101132603
Project title	Efficiency and Effectiveness of Training for Teachers' Pedagogical Digital Competence
Project acronym	EffecTive
Funding scheme	Horizon Europe
Coordinator	Tallinn University
Start date of the project	01.12.2023
Duration	36 months
Project website	https://project-effective.eu

Dissemination level

PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or European Research Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

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Executive summary

This report presents the research design of the pilot and intervention phase of the EffecTive project. The research design tests different types of effects of teacher training. We focus on effects on teachers' **Pedagogical Digital Competence** (PDC) as a direct effect of different training interventions and assessed directly after the training. We also assess the **Transfer of Training** effects which focus on the effects of training on teachers' teaching practices in the classroom and effects on student outcomes. We finally test the effects of training on **Equity**, meaning that training should not increase inequalities in student outcomes.

Drawing on an umbrella literature review (Wagner et al., 2024a), we devise our main independent variable as the **Complexity of Training**. This is defined as to how many different training methods a training intervention draws on. We define four broad categories of training methods as follows: Knowledge Instruction, Collaborative Design, Situated Learning and Mentoring/Coaching. If the training design of a particular training intervention incorporates more of these methods and, in particular, includes social and situated learning in it, it is assumed to result in a larger effect size on teacher PDC, classroom practices, and student outcomes.

We therefore have devised three **global hypotheses**, which all deal with a particular perspective on training effectiveness:

1. Effects on PDC: The higher the complexity of the training, the higher the effect on PDC.
2. Effects on Transfer of Training: The higher the complexity of the training, the higher the impact on teachers' practices and student learning.
3. Effects on Equity: The higher the complexity of training, the lower the observed inequalities in terms of student outcomes.

The report lists all constructs used as **dependent and control variables** that have been agreed to be used by all partners, as well as the recommended data collection instruments that have been proposed. The report also discusses potential biases in treatment design and sample selection and proposes different strategies to control for these, including pre-post test designs, the use of control variables and the use of control groups where feasible.

We present the design of **8 pilot studies** that have been completed realising 14 treatment conditions and involving over 500 teachers (pre- and in-service) across 5 different countries. The purpose of the pilot studies was to gather experiences with regard to treatment design and implementation of the trainings as well as the suitability of the instruments and procedures for data collection.

We then present the research designs of **14 intervention studies** that will be conducted in the following year. The intervention studies will realise 26 different treatment conditions (in pre- and in-service training) involving over 200 pre-service teachers, 500 in-service teachers and over 3000 students in testing the effectiveness of teacher training on PDC and the implementation in classrooms. The treatment conditions will be realised according to the training design framework presented in D2.1 (Seufert et al., 2024), ensuring alignment between the conceptualisation of training practices and the research designs. Results of the intervention studies will be used to assess the costs and benefits of the designed trainings (as described in the project's Cost-benefit Framework in D4.1, Wagner et al., 2024b) and will be a basis for a synthesising meta-analysis as well as a cost efficiency analysis that will eventually inform policy recommendations on the development of teacher PDC.

The current research design and plan presents a multi-site, quasi-experimental pretest posttest design that will be implemented across substantially different local teacher training contexts in five different countries. The ambitious endeavor was made possible by a highly flexible, iterative and participatory planning process that has set the foundation for a robust and rigorous roll-out in the upcoming year.

1. Introduction

EffecTive, as part of the Horizon Europe framework programme, undertakes a Research and Innovation Action with the primary goal of enhancing teachers' Pedagogical Digital Competence (PDC). Teachers' PDC is defined in the EffecTive project as a synergy of teachers' technological, pedagogical, and content knowledge (and their intersections), affective-motivational dispositions regarding technology integration in the classroom, their situation-specific skills (perception, interpretation, and decision-making), their cultural awareness, and their abilities to promote equity in a specific learning situation (Blömeke et al., 2015; Roth et al., 2023; Skantz-Åberg et al., 2022).

The aim of the project is to identify the key factors that can support teachers' PDC in terms of effectiveness and efficiency. One of the main objectives of EffecTive is to develop and refine a **comprehensive methodology to assess the impact of various PDC training programmes for teachers**. The evaluation focuses on how these training programmes influence teachers' pedagogical digital competence, their teaching practices, and the subsequent effect on student learning outcomes. The project prioritises understanding both the effectiveness and efficiency of the conditions under which PDC improvement occurs. We define **effectiveness** as a positive impact of the training on the quality of education (improved teachers' PDC, students' learning outcomes, and an inclusive learning environment). We define **(cost) efficiency** as the best way to transform costs into benefits. All this requires a wide range of data to be collected from students and teachers to evaluate the experience of training, effectiveness, and efficiency of the training.

The project therefore devised a staged, multi-site research design strategy (see Figure 1) to plan 12 quasi-experimental intervention studies in 5 countries. These studies were designed and conducted in two subphases. The pilot phase was conducted between April and November 2024 and was used for piloting newly developed modules or materials as well as research instruments. The intervention phase will commence in December 2024 and involve 12 quasi-experimental intervention studies in five countries to test hypotheses on the effectiveness of teacher training interventions developed in D2.1.

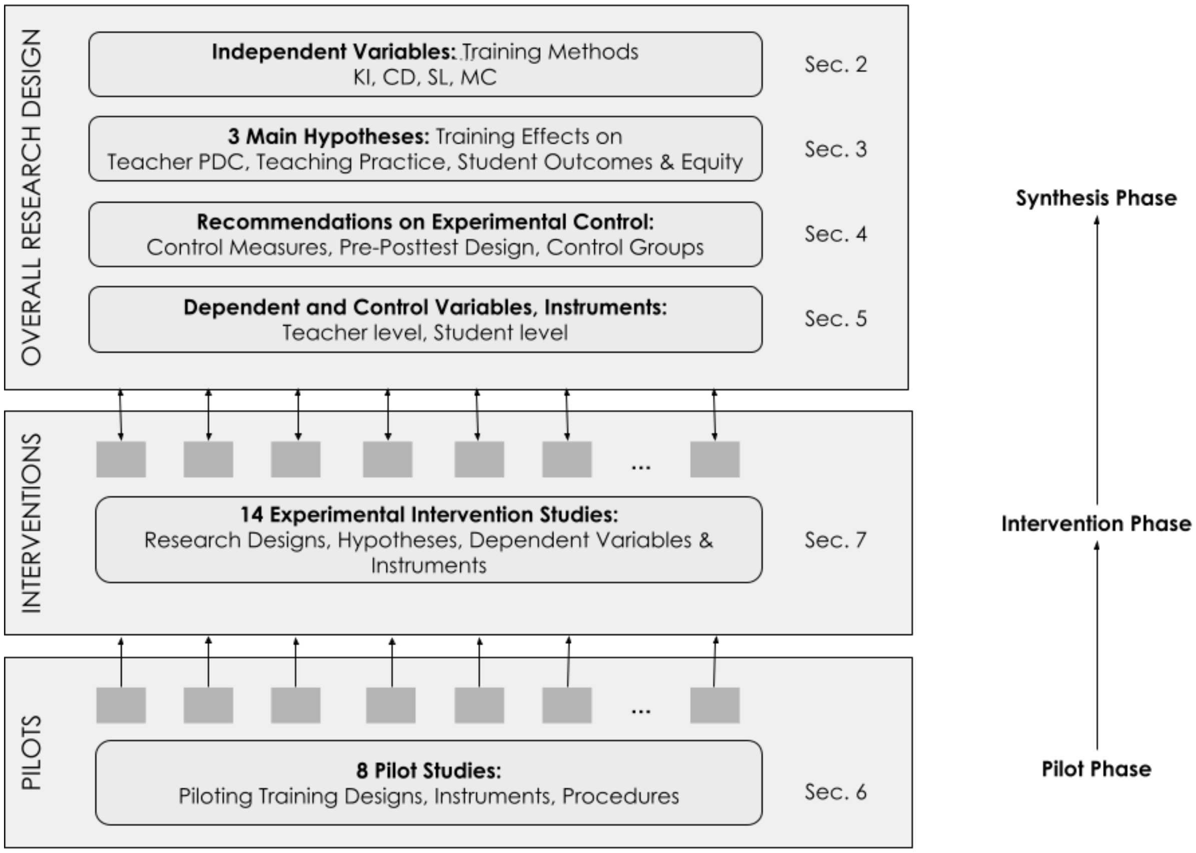

Figure 1: A multiple-site experimental research design strategy

The aim of Deliverable 3.1 is to provide an **overview of the various research designs and instruments for data collection** applied in the pilot and intervention studies (Sections 6 and 7). Because a particular emphasis is placed on the comparability of these research designs across interventions and countries to enable meta-analytic synthesis, a second aim of the deliverable is to **guide the research designs of the intervention phase by an overall research design** (see Figure 1 top). To develop this framework, we used the initial cost-benefit framework (D4.1), as well as the results of the two literature reviews on effective teacher training approaches (D1.2) and effective pedagogical approaches on the development of students' self-regulated (SRL) skills in technology-enriched classrooms (D1.3). Resulting from this, we developed three main hypotheses for the project, we developed and agreed on a set of measurement instruments, and we developed guidelines for ensuring experimental control. The overall research design of the project will be presented in Sections 2-5.

2. Effectiveness of teacher training for developing PDC

One of the central assumptions of the EffecTive project is that the effectiveness of teacher training for pedagogical digital competence (PDC) is determined by the complexity and design of the training methods employed. The project identifies four main training methods—Knowledge Instruction (KI), Situated Learning (SL), Collaborative Design (CD), and Mentoring and Coaching (MC)—each of which integrates **specific key training practices** that exemplify and operationalise these methods. Our review on the effectiveness of teacher training suggests that incorporating a variety of key training practices within these methods can enhance the development of teachers' PDC and result in stronger outcomes (Wagner et al., 2024a). Training designs that integrate a range of training practices, especially situated and social learning methods, are expected to have greater benefits for teacher learning. They enhance competence development and support implementation in the classroom. Decades of research have identified effective design elements (Wagner et al., 2024a). Table 1 summarises four training methods, each of which is associated with positive outcomes.

Table 1: Training methods for teacher PDC and hypothesised effects

Training Method	Hypothesised Effect	Reasoning
Knowledge Instruction (KI)	Teacher's technological or pedagogical **knowledge**	The structured nature of KI **enhances teachers' knowledge** by delivering foundational concepts, enabling them to integrate SRL and deeper learning strategies within technology-enhanced learning (TEL) environments while also **fostering constructivist learning principles** that emphasise active engagement and the integration of new information with prior knowledge.
Collaborative Design (CD)	Teachers' **integrated knowledge** and attitudes	Collaborative design in teacher professional learning enhances **integrated knowledge**, attitudes, and design and planning skills by actively engaging teachers in the co-design of teaching strategies and shared artefacts within a **supportive, socially mediated environment.**

Training Method	Hypothesised Effect	Reasoning
Situated Learning (SL)	Teacher's **skills** (e.g., situation-specific skills), perceived **value, and adoption**	Enhances teachers' **situation-specific skills** by providing opportunities for practical application in real contexts. Enhances teachers' **self-efficacy** and fosters stronger intentions to adopt new teaching practices, as they perceive the benefits of integrating new methods outweigh the associated costs.
Mentoring and coaching (MC)	Teachers' strengthened **self-efficacy,** confidence, and adoption.	The formation of intentions and adoption of **new behaviours** relies on opportunities for practical application, with mentoring providing ongoing, personalised support to help teachers bridge training and classroom implementation, enhancing their **instructional practices and confidence.**

- **Knowledge Instruction (KI)** primarily builds isolated knowledge, focusing on cognitive understanding of individual concepts in structured environments. This knowledge is often not immediately integrated into broader teaching practices.
- **Collaborative Design (CD)** fosters integrated knowledge by enabling teachers to co-design lessons, tasks, and teaching strategies. Through peer interaction, pedagogical and technological knowledge (e.g., TPACK) is combined into a cohesive framework.
- **Situated Learning (SL)** develops situation-specific skills by engaging teachers in real or simulated classroom settings, allowing them to adapt and practice knowledge in dynamic contexts, building practical, transferable skills.
- **Mentoring and coaching (MC)** enhances self-efficacy by providing ongoing, personalised support and feedback, helping teachers bridge the gap between theory and practice, and building confidence to adopt new methods.

While the **KI condition can be seen as baseline training**, each additional training method will add **social and situated learning methods (CD, SL and MC)** that increase the complexity and also increase the potential **effectiveness** of the training. The addition of situated and social learning methods means that knowledge is applied and practised in different settings; it is integrated and socially validated, helping to build confidence in the application of knowledge.

However, the addition of each training method will also come with **increased costs** in terms of time and resources. In terms of the effectiveness and efficiency of training, this is the main trade-off between benefits and costs that the project has set out to study (see deliverable D4.1).

3. Effects of training: The main hypotheses of the project

After describing our view on the complexity of the training intervention for PDC, we now turn to the effects of teacher training. Figure 2 shows a research model of the relationships between the training methods employed and a number of outcome variables. The left side shows the training interventions as being made up of several training methods (Complexity of Training) (see Sec. 2). The outcomes are classified according to the Kirkpatrick model of training evaluation (Kirkpatrick, 1959) into four interconnected levels of training effects: reaction, learning, behaviour, and results. On level 1, we measure immediate teacher reactions, such as training satisfaction and perceived quality of the training.

We assume that the higher the complexity of the training, the more profound the effects will be on levels 2, 3, and 4. As training incorporates situated and social learning methods (such as CD, SL, and MC), teachers not only experience a more intense development of their PDC, including growth in knowledge, situation-specific skills, and attitudes (on level 2). Alongside these gains, teachers also develop a stronger recognition of the value of these practices (task value) and an intention to adopt them in their teaching. This acts as a catalyst for behaviour change and adoption of new classroom practices (on level 3).

Teachers with advanced PDC are better equipped to integrate technology, make informed pedagogical decisions, and create engaging learning environments. Their intentional adoption of these teaching practices translates into enhanced student learning experiences, fostering cognitive engagement, skill development, and self-regulated learning (on level 4). Motivation ensures that these changes are not only implemented but also sustained. As teachers implement more equitable and inclusive practices that are grounded in their enhanced PDC, the disparities in student outcomes are likely to diminish, leading to more equitable interventions.

In addition to the main independent and dependent variables, the research model in Figure 2 also lists the main categories of control variables (right side). We assume that the effects of training on teachers' knowledge, skills, and attitudes will be mainly impacted by several teacher-level variables (such as their motivation to join the training or their prior training in PDC). We further assume that a change in teaching practices (on level 3) will be mainly impacted by a supportive environment of the school (such as a collaborative school culture or the technological support at the school). Finally, effects on the student level will depend on a few student-level variables (such as their socio-economic status).

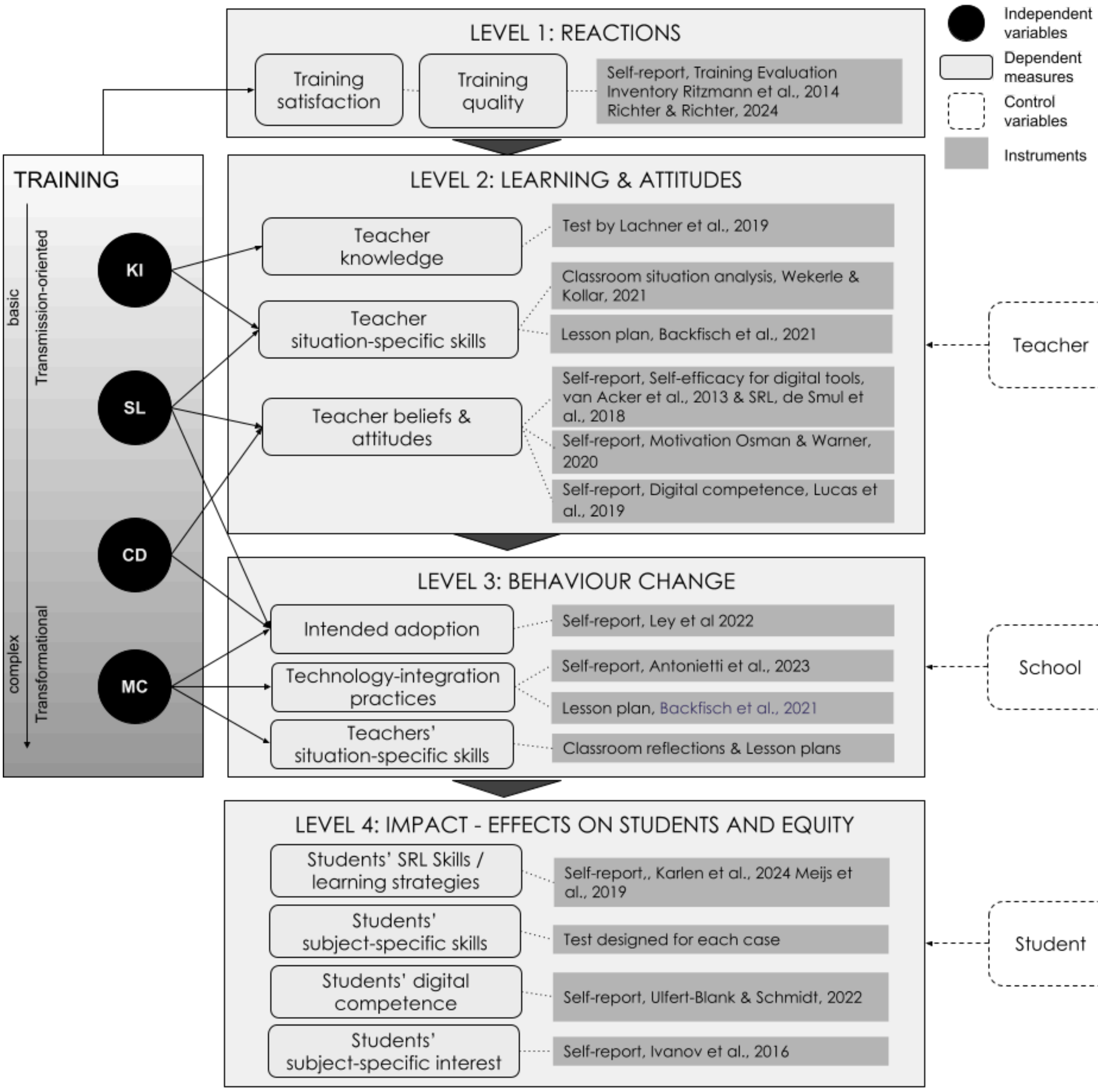

Figure 2: Assumed relationship between the complexity of training intervention and outcomes

To summarise, the EffecTive project takes three broad perspectives on the effectiveness of training, each of which has given rise to one main hypothesis that will be tested across the different interventions. The following three hypotheses will be covered in the next sections:

- Hypothesis 1 covers the effects of the training on **Teachers' PDC** and how different training practices will lead to different outcomes.

- Hypothesis 2 explores the **Transfer of Training** effects, meaning whether the training leads to any changes in teaching practices and student learning.
- Hypothesis 3 explores the effects of training on potential **educational inequalities** and looks at factors that could reduce these inequalities.

3.1. The "Complexity of Training" Hypothesis: Effects of training on teacher PDC

The complexity of training increases as more diverse key practices from different training methods are integrated (see Wagner et al., 2024a), especially more social and situated learning methods (SL, CD, MC). We assume that this will increase the effects on teachers' PDC on top of the baseline condition of KI.

Hypothesis 1: The higher the complexity of the training, the bigger the influence on teachers' PDC (knowledge, skills, and attitudes).

In addition to the general effect, we also expect specific effects of particular training methods on teachers' knowledge, skills, and attitudes as given by the four sub-hypotheses.

H1.1: KI (Knowledge Instruction) → Teacher knowledge

Hypothesised effect: The KI method is expected to enhance teachers' pedagogical and technological knowledge by increasing their cognitive understanding of key concepts, such as self-regulated learning and cognitive engagement.

This assumption originates from findings of our review of the associated key practices with this training method (Wagner et al., 2024a). The structured nature of KI, which efficiently delivers foundational knowledge related to both pedagogy and technology, equips teachers with the foundation to integrate these strategies into their instructional design. The cognitive acquisition of these concepts allows teachers to recognise the theoretical underpinnings necessary for applying SRL and deeper learning strategies within a technology-enhanced learning environment.

While KI methods aim to shape initial attitudes toward technology integration practices and develop lower-level situation-specific skills, we recognise that KI's primary effect lies in enhancing teachers' technological and pedagogical knowledge. KI, based on principles of constructivist learning, allows teachers to systematically build knowledge in controlled environments. KI is well-suited to teaching theoretical frameworks efficiently because it closely mimics the format of knowledge tests, i.e., factual recall and conceptual understanding. The KI approach is rooted in constructivist learning theories, which emphasise the importance of integrating new information with existing knowledge to build more comprehensive mental models (Piaget, 1973; Vygotsky, 1978). Huang (2002), building on the ideas of Dewey (1961) and Vygotsky (1962), highlights that constructivism emphasises active, real-world learning, builds on prior knowledge, involves reasoning processes, and relies on social interaction.

Key practices from the KI method, especially instruction and hands-on learning, are frequently used in PDC training interventions, underscoring the importance of aligning theoretical knowledge with practical application (Wagner et al., 2024a). In this regard, instruction often served as the initial step to equip teachers with foundational knowledge before moving on to other key practices (Yeh et al., 2021). This approach not only helps teachers to better understand the rationale for technology integration in the classroom (Tondeur et al., 2012) but also provides them with valuable opportunities to gain hands-on experience in authentic school settings. However, while teachers are generally found to be receptive to theoretical knowledge, many struggle to apply it in real classroom situations (Ning et al., 2021).

H1.2: CD (Collaborative Design) → Integrated knowledge, situation-specific skills, and self-efficacy

Hypothesised effect: The training practices of the CD method are expected to enhance teachers' complex knowledge and skills (e.g., integrated TPACK) and self-efficacy by promoting the co-design of teaching strategies through peer collaboration.

Collaborative design in teacher professional learning actively engages teachers in the creation of shared artefacts, such as lesson plans and instructional materials, thereby developing their design and planning skills. Grounded in Vygotsky's sociocultural perspective (1978), this approach underscores that knowledge is constructed through social interactions and collaborative processes. Vygotsky emphasised the importance of social contexts and cultural tools in learning, positing that understanding is developed through dialogue and shared activities, particularly through co-created artefacts. This collaborative process deepens learning as teachers negotiate meaning together and also builds their self-efficacy by providing a supportive social environment. According to our review (Wagner et al., 2024a), key training practices associated with Collaborative Design, such as analysing case studies and participating in design sessions, are frequently employed in training interventions for PDC. Collaborative approaches have shown promise in fostering teachers' TPACK skills (e.g., Jiménez Sierra et al., 2023; Røkenes et al., 2014; Smith et al., 2021; Yeh et al., 2021) by enabling teachers to share individual knowledge and experiences. This collaborative process creates a richer, collective understanding of TPACK that is enhanced by the diverse insights of participants (Yeh et al., 2021).

H1.3: SL (Situated Learning) → Teachers' situation-specific skills & beliefs and attitudes

Hypothesised effect: SL methods are expected to develop teachers' situation-specific skills and self-efficacy to apply the new teaching methods.

Teaching that is essentially situated requires teachers to adapt to real-time interactions with students (Borko, 2004). In this dynamic classroom context, teachers need to apply their knowledge flexibly while maintaining core principles that support student learning. They need to understand not only what to do but also how to do it and why it is important (Bereiter, 2014; Darling-Hammond et al., 2007). By engaging in relevant, contextualised tasks, teachers build confidence and increase their self-efficacy, which is essential for the successful application of new methods. Situated learning further supports teachers in perceiving and interpreting student behaviours and needs, thereby improving their situation-specific skills (Blömeke et al., 2015). When teachers perceive that the value and benefits of adopting new practices outweigh the associated costs, their motivation to integrate these practices into their teaching increases (Osman & Warner, 2020).

In our umbrella review, key training practices such as reflection/self-evaluation, rehearsal/field experience, and goal setting emerged as some of the most frequently applied practices in PDC training interventions (Wagner et al., 2024a). These practices appear to be particularly effective in developing teachers' situation-specific skills, thereby increasing their readiness to adopt new practices. Reflection and self-evaluation, for example, enable teachers to critically assess and adapt their teaching strategies when integrating technology (Hennesy et al., 2022; Smith et al., 2021), thereby fostering stronger intentions to use these tools in the classroom.

By providing opportunities for repeated practice and feedback in realistic settings, situated learning prepares teachers for immediate classroom challenges and fosters their ability to make informed, timely decisions that support students' self-regulated learning and deeper engagement. This dual emphasis on self-efficacy and skills development encourages a sustained commitment to the integration of technology-enhanced practices, driving continuous improvement in teaching and learning.

Table 2: Hypothesised effects of training methods on teacher outcomes

Training Method	Pedagogical or technological knowledge	Integrated PDC knowledge	Situation-specific skills—in training context	Beliefs and Attitudes
KI	++	+	++	o
CD	+	++	++	+
SL	+	++	+	++
MC	o	+	+	++

3.2 The "Transfer of Training" hypothesis: Effects of training on intended adoption, classroom practices and student outcomes

While Hypothesis 1 (see section 3.1) focuses on the type of training intervention that is assumed to provide effective training in terms of teachers' acquisition of knowledge, skills, and attitudes, the second hypothesis extends this perspective to a "transfer of training" perspective. As more complex training interventions enhance teachers' knowledge, skills, and attitudes and their integration to form PDC, they also facilitate the transfer of these competencies into classroom practice by linking training content and activities to workplace practices.

Hypothesis 2: Complexity of training transfers positively to the classroom and affects student learning outcomes.

Transfer to the actual work environment is more likely to occur through learning methods that apply knowledge in different social settings. This happens especially through more intensive exchange with other teachers (CD), through situated learning in one's own classroom (SL), or through mentoring (MC). In the project, we assume that transfer is initially indexed by an increased intention to adopt innovative teaching strategies (see, e.g., Ley et al., 2022). Ultimately, this will lead to changes in classroom practices and thus to improved student outcomes, including subject-specific skills, enjoyment, and self-regulated learning skills.

H2.1: CD (Collaborative Design), SL (Situated Learning) → Teachers' Intended Adoption of new teaching practices

Hypothesised effect: The inclusion of Collaborative Design (CD), Situated Learning (SL) will increase the teachers' perceived value and intentions to adopt technology-enhanced learning methods in their classroom teaching.

Job-embedded professional development grounded in authentic classroom practice enables teachers to construct meaning from their experiences and effectively apply new knowledge (Girvan et al., 2016; Lave & Wenger, 1991). This approach not only facilitates the transfer of skills into practice but also influences teachers' intentions to adopt innovative practices (Ley et al., 2022). Furthermore, by incorporating rehearsal/field experience into teacher training, participants' attitudes towards technology shift from a focus on personal skills to the development of teaching skills as teachers gain practical experience (Røkenes et al., 2014), which may lead to a strengthening of the perceived value of these methods.

The hypothesis is grounded in several models establishing "behavioural intention" as a critical link between attitudes and actual behaviour (e.g., Granić & Marangunić, 2019) and thus as an important link between teacher training and the teachers' PDC knowledge, skills, and attitudes (as discussed under Hypothesis 1) and improved classroom practices of the teacher. In addition to the important role of positive attitudes, perceptions of ease of use and usefulness, as well as perceived social norms, influence teachers' intentions to adopt new teaching practices. Positive attitudes formed during training can increase motivation to implement innovative strategies, leading to improved teaching practices that enhance student learning. By fostering positive perceptions during training, teachers are more likely to integrate technology effectively.

H2.2: *SL (Situated Learning), M (Mentoring)* → Technology integration practices, mediated by teachers' self-regulated learning skills.

Hypothesised effect: Mentoring is expected to improve teachers' attitudes and support the practical application of new methods, leading to stronger adoption intentions by providing ongoing guidance to overcome challenges and apply training in the classroom.

Models on the Transfer of Training posit that training is more likely to be translated into practical applications in the classroom when the context of learning and application are similar and trainees can make clear connections between the two settings (Blume et al., 2010). This process is critical to ensuring that newly acquired competencies are retained and effectively applied in real-life classroom scenarios, ultimately benefiting student learning.

Demonstrating new behaviours in practice requires opportunities to apply skills and support during implementation. Mentoring provides a sustained link between training and practice, helping teachers to overcome initial challenges. Collins and Kapur (2014) highlight mentoring as a core element of cognitive apprenticeship, providing structured, personalised support. Grounded in social constructivist and situated learning, coaching provides individualised guidance to integrate theory and practice, improve instructional skills, encourage reflective practice (Schön, 1983), and build confidence in novel strategies.

Key training practices associated with mentoring and coaching, although less frequently implemented, show significant potential for supporting teachers to integrate new methods (Wagner et al., 2024a). Research indicates that observing experienced teachers using technology effectively can inspire and motivate participants by providing tangible examples of practical applications (Tondeur et al., 2012). In addition, modelling by mentors has been shown to equip teachers with essential skills for technology integration, facilitating the translation of training into classroom practices (Røkenes et al., 2014; Teo et al., 2021). Despite its potential, empirical evidence confirming the impact of mentoring on classroom technology use remains limited (Kay, 2006). **Teachers' self-regulated learning (SRL)** skills play a crucial role in facilitating learning transfer. This is because the transfer process aligns with key principles of SRL, such as planning, implementation, and reflection (Zimmermann, 2002). Teachers' motivation to engage in SRL, coupled with their metacognitive skills, is crucial in ensuring the effective application of learnt concepts in practice.

H2.3: SL (Situated Learning) and MC (Mentoring) → Situation-Specific Skills (in practice)
Hypothesised Effect: Training that integrates elements of SL or MC fosters the development of teachers' situation-specific skills, enabling them to effectively notice, interpret, and make decisions about students' engagement and SRL within the context of technology-integrated classroom practices.

The development of situation-specific skills—such as perception, interpretation, and decision-making—can be effectively initiated in simulated learning settings. These training environments, which do not require authentic classroom contexts, provide a structured and scaffolded space for teachers to practice and refine these skills. The process can begin with demonstrated examples, offering clear models of how to approach and resolve specific classroom scenarios before progressing to more complex tasks.

However, research shows that teachers' noticing can be further developed and manifested in practical teaching situations (Weyers et al., 2024). Furthermore, Jessup (2023) has highlighted the situated nature of teachers' noticing (perception) skills, emphasising that these skills are context-dependent and shaped by the sociocultural context of teaching. Therefore, some methods, such as Situated Learning (SL) and Mentoring (MC), are considered more effective in supporting the implementation of these skills in authentic situations. These methods emphasise reflecting on experiences and integrating both theoretical and contextual elements to enhance their practical application. Similarly, SRL skills are crucial for learning transfer, as the process aligns with SRL principles like planning, implementation, and reflection (Zimmermann, 2002).

H2.4: ***SL (Situated Learning), MC (Mentoring) → Students' Subject-Specific Skills***
Hypothesised Effect: Training leads to improved classroom practices and improved student learning outcomes in terms of subject-specific skills.

Regarding classroom practices, our review (Wagner et al., 2024a) found that many training programmes led teachers to adopt technological tools while gaining a deeper understanding of how to integrate them effectively into the classroom. This made teaching more dynamic and better tailored to students' needs (Atmacasoy & Aksu, 2018; González et al., 2024; Hennessy et al., 2022; Perry et al., 2021; Røkenes et al., 2014; Smith et al., 2021; Wu, 2023). Another significant impact was seen in the promotion of student-centred teaching. The training enables teachers to design classrooms that promote active student engagement and collaborative learning, creating more opportunities for students to actively participate in the learning process (Huang et al., 2022; Smith et al., 2021; Wang et al., 2018).

Regarding student outcomes, there is a limited number of studies that specifically address the effects in this area (Wagner et al., 2024a). The existing evidence suggests that thoughtful integration of technology in the classroom can improve student learning outcomes, but the results are mixed. While some studies report significant improvements in subject-specific areas, such as reading comprehension and mathematics, others show no substantial change or only minimal, statistically non-significant gains in subjects such as mathematics and biology (Bragg et al., 2021). This mixed evidence highlights the critical role of context and implementation in determining the effectiveness of educational strategies.

H2.5 SL (Situated Learning), M (Mentoring) → Students' Self-regulated Learning (SRL) Skills

Hypothesised Effect: Training leads to teachers' SRL self-efficacy beliefs and SRL practices, which in turn lead to students' improved SRL skills.

SRL refers to the process by which students actively control and manage their learning, including setting goals, monitoring their progress, employing learning strategies, and adjusting their approach as needed (Zimmerman, 2002). SRL skills are crucial in technology-enhanced learning (TEL) contexts, where students often engage with digital tools and resources in a less structured environment compared to traditional classrooms (Pintrich, 2004). The ability to self-regulate is associated with deeper cognitive engagement and more effective use of learning technologies (Winne & Hadwin, 1998). Research highlights that **students with strong SRL skills** are better equipped to navigate the complexities of TEL environments, as they can independently manage distractions, seek out additional resources, and optimise their study strategies using digital tools (Azevedo & Cromley, 2004). **Motivation and engagement** in TEL contexts are significantly higher when students can set clear goals, monitor their progress, and reflect on their learning (Schunk & Zimmerman, 2007). Thus, developing SRL skills in students can directly enhance their ability to maximise the benefits of TEL practices, leading to improved learning outcomes (Dabbagh & Kitsantas, 2012). **Teacher training** is crucial in fostering an environment that promotes SRL skills in students, particularly for technology-integrated classrooms. **Professional development programmes** that focus on SRL and TEL equip teachers with the knowledge and skills to design learning experiences that encourage student autonomy, strategic thinking, and active engagement (Desimone & Garet, 2015). These programmes often emphasise both **pedagogical strategies** for integrating technology (e.g., using learning management systems or digital tools) and **SRL-enhancing practices** such as scaffolding self-reflection and goal-setting activities (Bannert, 2009). Research has shown that **teachers' self-efficacy—**their belief in their ability to influence student outcomes—is closely related to their teaching practices and their willingness to integrate innovative teaching strategies, including SRL and TEL practices (Tschannen-Moran & Hoy, 2001). Teachers who receive training in **SRL strategies and technology integration** tend to develop a greater sense of self-efficacy in implementing these approaches in their classrooms (Bandura, 1997; Schunk, 1995). They are more likely to design lessons that promote student-centred learning, including opportunities for students to practise self-regulation in digital environments (Ertmer & Ottenbreit-Leftwich, 2010).

Mechanisms of influence:

1. Training and pedagogical practices:

- Training programmes that focus on the **integration of SRL and TEL** enhance teachers' ability to design activities that promote self-regulation, such as setting learning goals, monitoring progress, and reflecting on outcomes (Loyens, Magda, & Rikers, 2008).
- Teachers with **a deeper understanding of SRL concepts** are better able to model these strategies and integrate them into their lesson plans (Pintrich, 2000). This modelling and explicit instruction create a classroom culture that values self-directed learning and critical thinking, making students more receptive to using TEL tools effectively.

2. Improved SRL skills and student motivation:

- Students with improved SRL skills become **more intrinsically motivated** because they see a clearer connection between their efforts and outcomes (Ryan & Deci, 2000). This increased motivation is particularly beneficial in TEL settings, where learning activities often require sustained engagement and persistence (Artino, 2008).
- With improved self-regulation, students are better able to adapt to TEL tools such as simulations, games, and adaptive learning platforms that require active participation and self-directed exploration (Kitsantas, Dabbagh, & Chirinos, 2016).

3. Impact on student learning outcomes:

The combined effects of **teacher training** and **enhanced SRL skills** lead to improved learning outcomes in TEL environments. Research suggests that students in classrooms where teachers emphasise SRL strategies demonstrate **higher academic achievement**, greater use of learning strategies, and better adjustment to digital learning environments (Greene & Azevedo, 2007).

Table 3: Hypothesised effects of training methods on teachers' practices and students' outcomes

Training Method	Intended adoption (T)	Technology integration practices (T)	Situation-Specific Skills in real classroom practice (T)	Subject-Specific skills (S)	Self-regulated learning skills (S)
KI	o	o	o	o	o
CD	++	o	o	o	o
SL	++	++	++	++	++
MC	+	++	++	++	++

3.3 The "Equity by Inclusion" hypothesis: Effects of training on equity and inclusion

Integrating technology into instruction does not only require teachers to learn complex new skills and integrate knowledge; it also requires their students to adjust to teaching approaches that are more flexible and often prioritise student-centred learning. It has been shown that this change is demanding, may raise students' cognitive load, and require students' self-regulated learning skills. Given the strong association between students' SRL levels and their socio-economic background (Thomas et al., 2019), there is a risk that not all students benefit equally from these higher levels of complexities related to PDC. Well-trained and more inclusively aware teachers are better equipped to support disadvantaged students in coping with more demanding learning practices and to improve students' self-regulation skills (Ma, 2021). Therefore, for EffecTive, it is important to support the learning of all students and to build capacity to foster equity and inclusion in the technology-enhanced learning (TEL) classroom. For that, in addition to developing our understanding of the role of teacher and students' SRL in supporting equity and inclusion in TEL classrooms, the role of inclusion awareness of teachers is analysed in those associations.

Hypothesis 3: The higher the level of complexity of training interventions in integrating PDC (e.g., SL+CD+MC vs KI), the lower the achievement gaps (i.e. inequity) in student learning outcomes (e.g., fewer heterogeneous treatment effects in student outcomes).
Although the introduction of technology-enriched lessons may benefit students by providing adaptability and customisation to accommodate student needs (e.g., assistive technologies), there is a risk that the introduction of technology increases inequality for students from disadvantageous backgrounds (Eynon & Malmberg, 2021). Hypothesis 3 assumes that higher complexity in training interventions enhances teachers' PDC and SRL (see H2), which, in turn, increases their ability to transform classroom practices into more equitable and inclusive learning environments (e.g. inclusive awareness of teachers), eventually reducing students' achievement gaps (Krüger, 2019).

At the student level, we differentiate between equity and inclusion, expecting related but distinctive effects of these two dimensions on student learning gains (OECD, 2023; Cerna et al., 2021). **Equity** is conceptualised as student characteristics or needs (e.g., gender, age, special educational needs) and background (e.g., socio-economic background) potentially influencing learning outcomes, and various specifications are tested to be able to account for cross-country differences in the relevance of these disadvantages (Kim et al., 2021; Ma, 2021). **Inclusion** is conceptualised as access to quality of education for all of the students and operationalised/measured through the student-level sense of belonging scale (Dickson et al., 2016; Chiu et al., 2016).

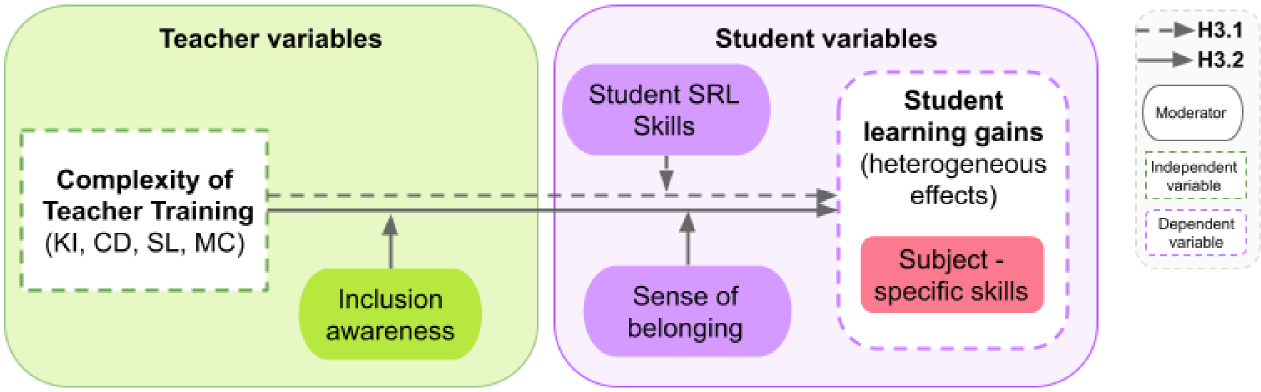

Figure 3: Hypothesised effects of training on equity

H3.1. Students' SRL moderate the effect of TEL practices on achievement gaps (i.e. inequity).

Teachers' technology integration practices may impact students differently based on their background (Kim et al., 2011). For instance, students with higher socioeconomic status and higher prior knowledge may benefit more from TEL than those with lower socioeconomic status (SES) and lower prior knowledge (Njeri & Taym, 2024). Research suggests that students from lower SES, on average, tend to have lower self-regulated learning (SRL) skills compared to their higher SES peers. This is influenced by various factors related to SES, including access to resources, environmental stability, and exposure to learning opportunities. Hence, students' individual SRL could help close the achievement gap, as SRL allows students to take control of their own learning process regardless of the limitations of their background (Karlen et al., 2024). Enhanced SRL skills in students are expected to improve their capacity and motivation to engage with and benefit from technology-enhanced learning practices (Figure 3). Furthermore, TEL environments that incorporate SRL strategies support deeper learning and knowledge retention by allowing students to adapt their learning processes and access resources that align with their individual needs (Azevedo & Cromley, 2004).

H3.2 The complexity of training (e.g. SL, CD, MC vs KI) enhances teachers' inclusion awareness, thereby lowers the student achievement gap in terms of equity and inclusion.

Studies have shown that technology has the potential for creating inclusive learning environments (Ahmad et al., 2024). However, the effective use of technology for inclusion requires both awareness of inclusive principles and the skills to implement them. For instance, teachers' awareness of inclusive education principles can play a crucial moderating role, as teachers could use their previous knowledge about inclusive practices to better apply technology in ways that support all learners (European Agency for Special Needs and Inclusive Education, 2024). As indicated in H1 and H2, knowledge, skills, attitudes and behavioural change expected from more complex training interventions (e.g, SL, CD, MC) equip teachers to recognise the various factors influencing the effectiveness of their practices, and to adapt and implement their practices accordingly. These include, among other things, adaptive instruction techniques, differentiated assessment methods, and classroom management for diverse learners (Nimante & Kokare, 2022).

Inclusive classrooms are characterised by teachers' awareness of and implementation of inclusive teaching practices that leads to higher students' sense of belonging. In classrooms with a higher students' sense of belongingness (e.g. inclusive classrooms), the achievement gaps are smaller (e.g. equity in outcomes) than in those classrooms with lower sense of belongingness (Figure 3). Thus, H3.2 examines teachers' inclusion awareness effects on students' sense of belongingness that is expected to reduce student achievement gaps (i.e. **equity by inclusion hypotheses**).

Table 4: Hypothesised effects of training methods on equity, inclusion, and outcomes

Training Method	Equitable outcomes	Inclusive outcomes	SRL skills moderate equity and inclusion	Inclusion Awareness moderate equity and inclusion
KI	o	o	o	+
CD	+	+	o	+
SL	++	++	++	++
MC	++	++++	+	++

4. General research design

The primary aim of the EffecTive research design is to establish cause-effect relationships between training interventions and their outcomes through a multiple-study, quasi-experimental, pre-post-test design, which serves as the foundation for subsequent intervention studies. By this approach we evaluate whether and how the complexity of training methods influences teachers' PDC, classroom practices, and student outcomes.

This research design spans two implementation contexts: (1) the teacher training context, where the effects of the training on various teacher learning outcomes are evaluated, and (2) the classroom implementation context, where the focus shifts to observing teaching practices and student outcomes (see Figure 4).

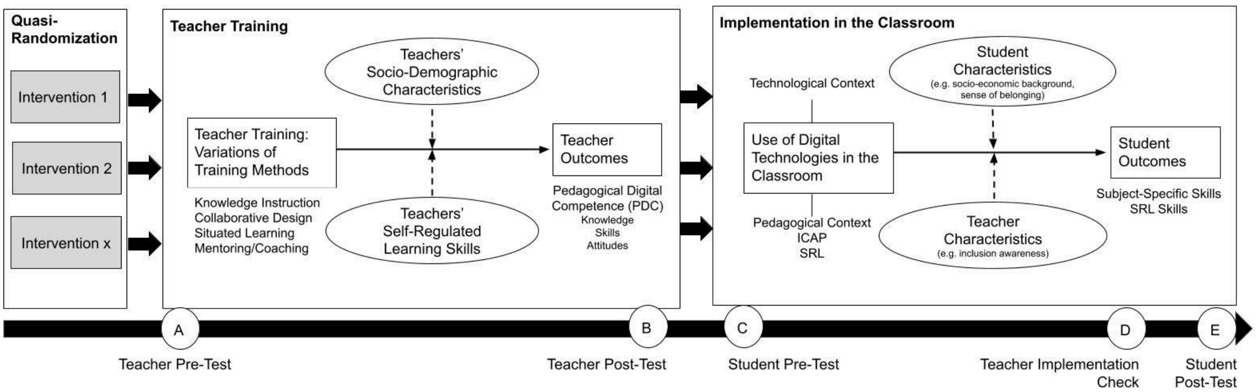

Figure 4: General research design for the EffecTive project

4.1 Experimental conditions

The experimental conditions are structured by combining different training methods, which increases the complexity of the training. By integrating multiple training methods, each condition provides a learning experience that targets different aspects of teacher development in PDC (knowledge, skills, and attitudes). The training methods include:

- **Knowledge instruction (KI):** provides foundational content and conceptual understanding relevant to teaching practices and technology integration.
- **Collaborative design (CD):** engages teachers in co-designing practices or learning materials, encouraging teamwork and practical application of knowledge.
- **Situated learning (SL):** fosters the application of new knowledge and skills in real classroom contexts, integrating theory with practice.

- **Mentoring/Coaching (MC):** Offers personalised guidance and feedback from experienced mentors or coaches, supporting individual growth and reflection.

4.2 Measurement times

The EffecTive project employs a pre-post-test design with multiple measurement points across the teacher training and classroom implementation contexts. The measurement times are structured as follows:

- **A. Teacher pre-test**: conducted before the start of the teacher training intervention to establish baseline measures of teachers' PDC (knowledge, skills, attitudes).
- **B. Teacher post-test**: administered immediately after the completion of the teacher training intervention to assess changes in teachers' PDC (knowledge, skills, attitudes) resulting from the training intervention.
- **C. Student pre-test**: implemented at the beginning of the classroom implementation phase to measure students' initial levels on relevant outcomes variables (e.g. subject-specific skills, digital competence, SRL skills)
- **D. Teacher implementation check**: carried out during the classroom implementation phase to monitor teachers' fidelity of implementation and application of learnt practices. This may involve classroom observations, teacher logs, or other forms of process data collection.
- **E. Student post-test**: conducted at the end of the classroom implementation phase to evaluate changes in student outcomes and assess the impact of teachers' newly acquired practices on student learning.

This measurement schedule allows for the examination of both the immediate effects of the teacher training intervention and its subsequent impact on classroom practices and student outcomes. The multiple measurement points enable a comprehensive analysis of the intervention's effectiveness across different stages of implementation and stakeholder groups.

4.3 Addressing biases in experimental design

As the EffecTive intervention studies will take place in real-world training and classroom environments, we can assume a high level of ecological validity. On the downside, such studies sometimes lack internal validity. It is therefore important to be aware of potential biases and address these in the design or analysis. In this section, we discuss two such biases in the project.

4.3.1 Potential biases related to the design of the treatment

The teacher training interventions that are listed in Section 7 may be designed by different entities, including:

- **Researchers**: In some studies, the training is conceptualised and structured by the research team, ensuring that the content of the training aligns closely with the specific goals and objectives of the EffecTive project. However, this alignment may introduce a limitation known as the experimenter effect, where the researcher's involvement may inadvertently influence participants' perceptions and responses.
- **Teacher training institutions**: In other instances, established training institutions design the teacher training intervention. While these interventions are less likely to be biased by the researchers' influence, the content may not be as well aligned with the specific goals of the EffecTive project, potentially impacting the relevance and effectiveness of the training for the participants.

As a result, the way the training was designed should be taken into consideration as one of the control variables used in the analysis phase. This way, potential biases could be detected.

4.3.2 Potential biases in sample selection

The sample selection process in the EffecTive project needs to take into account a number of practical constraints that are well known in training research. These constraints can lead to several biases, which are discussed next:

- **Self-selection to training groups**: Teachers are allowed to self-select into different training groups based on their preferences, schedules, and professional development needs. This approach enhances motivation and engagement but may introduce potential selection bias, which will be accounted for in the analysis (see section 4.4).
- **Composition of teachers in the training intervention**: The composition of participating teachers can vary based on the specific training intervention.
    - **Whole-school approach**: In some studies, teachers from a single school participate collectively in the training. This approach fosters collaboration, enabling teachers to work together on shared goals and strategies, potentially enhancing the implementation of learnt practices within their specific context.
    - **Mixed-group approach**: In other instances, teachers from multiple schools come together for the training. This diversity can enrich the learning experience by allowing for the exchange of varied perspectives, practices,

and challenges faced across different educational contexts. However, the ability of teachers to implement what they have learnt in their classrooms may depend significantly on contextual factors, such as technology availability, resource access, and institutional support, which can vary widely across different school environments.

- **Ethical considerations:** Ethical standards are maintained throughout the selection process, ensuring that participation is voluntary and that teachers are informed of their rights and the purpose of the research. Special attention is given to avoid any bias or coercion in the selection process, promoting a fair and equitable opportunity for all interested teachers to participate.

4.4 Establishing experimental control

As was discussed in the previous section, achieving the rigour of randomised control trials can be challenging in educational and training research due to practical constraints. Consequently, the intervention studies within the EffecTive project (see Sec. 7) are structured as quasi-experimental interventions. To ensure the validity of the findings and to mitigate the impact of potential confounding variables, the research designs incorporate several strategies for experimental control. We discuss three of these and describe how experimental control is maintained in the design and the analysis phase.

4.4.1 Pre-post test design (required for all studies)

Pre-post test designs control for non-random differences in the pretest score of the participants, which could be a result of the self-selection into treatment groups.

Design: In both training and classroom settings, all dependent variables will be assessed through pre- and post-test measures. This design allows for the evaluation of changes in outcomes assumed to be a direct result of the interventions implemented (assuming there are no confounding variables).

Analysis: The data analysis will primarily focus on learning gains (i.e., post-test score minus pre-test score) as dependent measures in the evaluation of training effects. Additionally, post-test scores may be treated as dependent measures, while pre-test scores can be included as covariates to control for baseline differences among participants. This approach enhances the robustness of the analysis by accounting for initial conditions.

4.4.2 Control variables (required for all studies)

The self-selection to treatment groups can lead to a non-random distribution of certain confounding variables (such as the motivation to participate in the training). At least with respect to known confounding variables, the inclusion of control measures allows for controlling for biases arising from these.

Design: In both training and classroom settings, a variety of control measures will be implemented that have been shown to significantly affect training outcomes. These controls are essential for isolating the effects of the training interventions. The variables and their measurement are covered in more detail in Section 5.

Teacher variables used as controls:

- **Voluntary participation in training**: Differentiating between teachers who choose to participate and those who are required to take part helps to account for variations in engagement and motivation.
- **Prior job experience:** The number of years and types of experience in teaching can impact how teachers engage with new training content.
- **Pedagogical pre-training:** Previous training in pedagogy may influence the readiness and receptiveness of teachers to new methodologies.

Student variables used as controls:

- **Baseline academic achievement**: Initial assessments of student achievement can provide a reference point for measuring growth.
- **Demographic variables:** Factors such as age, gender, and socioeconomic status can impact learning outcomes and will be controlled for in the analysis.
- **Classroom environment:** Variables related to classroom settings, such as class size and resource availability, will also be considered to ensure a comprehensive understanding of the context in which learning occurs.

School variables used as controls:

- **Contextual/structural variables:** Factors such as type of school, school size, and location of school can impact teacher performance, student outcomes, and school development and will be controlled for in the analysis.
- **Organisational variables:** Factors such as teacher staffing, school leadership, and support from the school principal can impact teacher satisfaction and student performance and will be controlled for in the analysis.

- **Technological variables:** Factors such as technological quality, learning management systems, and the importance of digital technology in school can impact classroom management, teaching methods, and student engagement and will be controlled for in the analysis.
- **Collaboration and social variables:** Factors such as teachers' informal and formal collaboration can impact peer support and will be controlled for in the analysis.

Analysis: Control measures will be incorporated into the statistical analysis to mitigate confounding variables. These variables will be used as covariates in analysing training effects, enhancing the validity of the results. In some cases, the control variables will be used as moderator variables in case differential effects of the training in two or more subgroups are of interest.

4.4.3 Control Conditions (strongly recommended for all studies)

Control group designs allow controlling for the effects of non-treatment-related variables, such as the passing of time, the learning through other sources than the training, or measurement effects (e.g., learning or attitudinal change that results from the measurement, not the training).

Design: Establishing control conditions in educational research poses ethical considerations and practical constraints, making it impractical to mandate for all individual studies. However, certain designs utilising control conditions are feasible and have been recommended for implementation within this project.

Possible control group designs on the **teacher level** (see Figure 5):

1. **Parallel non-training control group:** A comparable group of participants is recruited concurrently with the training implementation but does not participate in the training. Pre- and post-test measures will be collected for this group. To acknowledge their participation, the control group should receive personal feedback regarding their scores on the survey instruments.
2. **Waiting control group:** A comparable group of participants is recruited alongside the training implementation and is assessed with pre- and post-tests without undergoing training. This group will be given the opportunity to participate in the training at a later date, thereby allowing for follow-up comparisons.

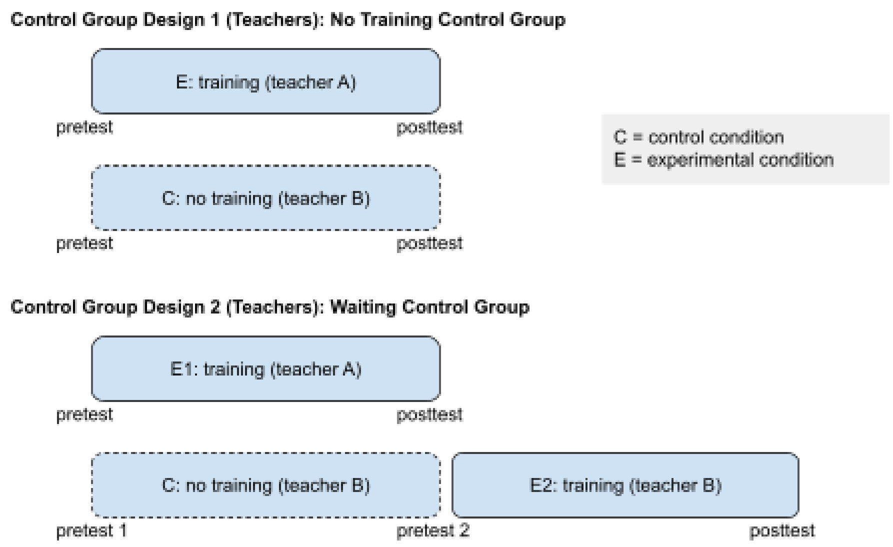

Figure 5: Control group designs for the teacher level

Possible control group designs on the **student level** (see Figure 6):

1. **Parallel non-training control group:** A class comparable to the experimental class is recruited from a different teacher who did not participate in the training.

2.1 **Waiting control group 1:** Classes from the waiting control group of teacher B (see 2 above) are used as a control group prior to their participation in training, allowing for assessment of changes over time.

2.2 **Waiting control group 2:** A parallel or the same class is recruited from teacher A, who participates in the training but is tested before the training begins, enabling a pre-training baseline for comparison.

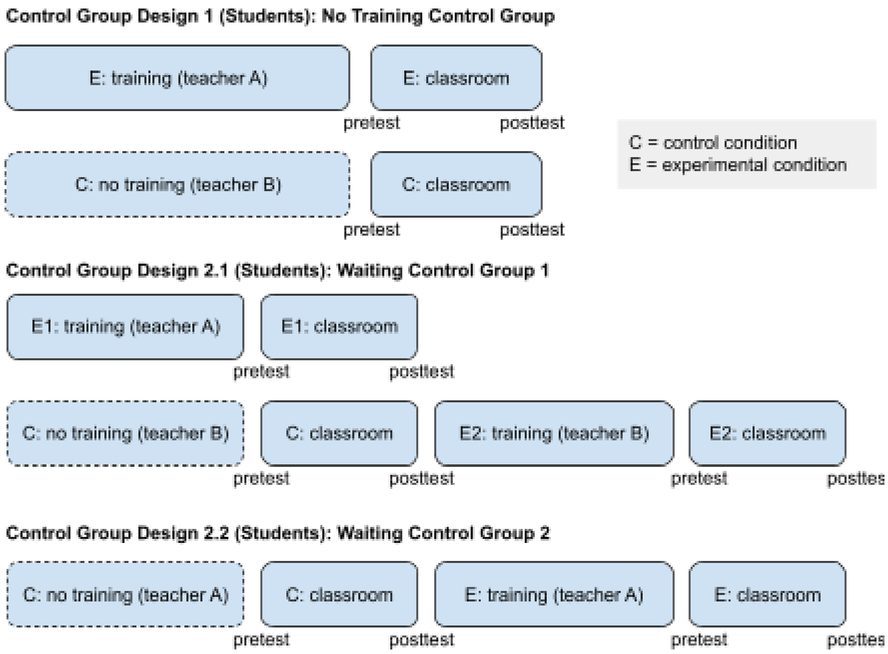

Figure 6: control group designs for the student level

Analysis: In all cases, data analysis will focus on comparing the experimental groups (E) to the control groups (C) in terms of either learning gains or post-test scores, with pre-test scores utilised as covariates. This analytical approach ensures a rigorous evaluation of the training's effectiveness across various contexts and participant characteristics.

5. Measures and instruments

The initial selection of instruments was proposed during the project's conceptual phase, where the consortium collaborated on developing the project idea. Pre-pilot studies were conducted in several cases, providing insights into the practical application of the instruments. Instruments were then aligned with the theoretical framework of the project, with subgroups formed based on partners' expertise and experience. This effort led to a refined list of instruments selected to measure key constructs of the project.

A combination of validated instruments and project-specific tools was selected to ensure reliability and relevance. For example, validated instruments, such as those measuring clarity and structure, practical relevance, cognitive activation, and collaboration (Richter & Richter, 2024), were chosen to assess key constructs like training quality. These instruments were selected based on their proven validity, ensuring they accurately measure the intended constructs.

These are complemented by instruments specifically developed or adapted for the project, such as customised lesson plans and situation-specific skills evaluation. Those instruments are designed to capture contextually relevant data on how teachers apply technology integration strategies in real classroom scenarios.

- **Knowledge**: Pre- and post-intervention tests were developed to evaluate teachers' technological pedagogical knowledge (TPK) and students' subject-specific knowledge. For example, we used the original situational TPK test by Lachner et al. (2019) and adapted it to align with the specific content of a case.
- **Situation-specific skills**: Additionally, instruments were developed to understand how effectively teachers can perceive, interpret, and make decisions in technology-enhanced classrooms. For example, we adapted a scenario analysis to align the context and tools of each case.
- **Lesson plans:** Teachers' lesson plans were collected as artefacts within the post-test to evaluate how their practices evolved throughout the intervention. The quality of technology integration in these lesson plans will be a key focus of analysis.
- **Students' subject-specific skills**: These are measured differently in each case due to variations in topics; however, the testing framework allows for the calculation of knowledge gains and skill development within each specific topic and domain.

To ensure that instruments are culturally appropriate and understandable in all participating countries, a localisation and translation process was implemented:

- **Translation**: Instruments were translated into the local languages of each country using a forward and backward translation process to preserve the original meaning.
- **Localisation**: Instruments were adapted to fit local contexts, ensuring that questions and terms are relevant and understandable for the teachers and students in each country.
- **Pilot testing**: The localised and translated instruments were pilot tested to identify any remaining issues with clarity or relevance, and adjustments were made based on feedback before the final versions were deployed.

5.1 Level 1 - Reactions

In Level 1, we evaluate participants' immediate reactions to the teacher training in a post-test, focusing on their satisfaction. This is essential to understand whether the training is well-received and engaging, as it may influence their motivation to apply the learnt concepts. The table below lists the variables, identifiers, number of items, an example, and the references used in level 1.

Table 5: Variables for evaluating training satisfaction (Level 1)

Variable	Identifier	Nr of items	Example	Reference
Training Satisfaction				
Subjective enjoyment	l1enjoy	3 items	"Overall, I liked the training."	Ritzmann et al., 2014
Perceived usefulness	l1useful	4 items	"I find the training useful for my job."	Ritzmann et al., 2014
Perceived difficulty	l1diff	4 items	"The contents were comprehensible."	Ritzmann et al., 2014
Attitude towards the training	l1attitude	3 items	"I will apply what I learned to my day-to-day work. "	Ritzmann et al., 2014
Subjective knowledge gain	l1know_gain	3 items	"I have the impression that my knowledge has expanded on a long-term basis."	Ritzmann et al., 2014
Training quality				

Clarity and structure	I1clarity	5 items	"The goals of the course were clearly stated."	Richter & Richter, 2024
Practical relevance	I1relevance	4 items	"The discussion of the contents was based on real examples from school practice."	Richter & Richter, 2024
Cognitive activation	I1cog_act	6 items	"My prior knowledge was incorporated into the course."	Richter & Richter, 2024
Collaboration	I1collab	3 items	"The course allowed for work in small groups."	Richter & Richter, 2024

5.2 Level 2 – Knowledge, skills & attitudes

In level 2, we assess the extent to which participants have acquired the intended knowledge, skills, and attitudes from the training. When it came to the question of self-regulated learning, there were several ways to measure this construct. Therefore, each case partner independently decided how to assess SRL and adapt it to fit their specific training. The table below lists the identifier, constructs, number of items, an example, and the references used in level 2.

Table 6: Variables for evaluating knowledge, skills and attitudes (Level 2)

Variable	**Identifier**	**Nr of items**	**Example**	**Reference**
Knowledge				
Conceptual TPK: Technological potential of ICT	I2tech_pot	5 items	"Digital information and communication technologies as an information and presentation means to offer the potential that…"	Lachner et al., 2019
Conceptual TPK: Educational psychology principles of ICT	I2EdPsych_prin	3 items	"Students learn better when learning with digital texts and pictures,..."	Lachner et al., 2019

Situational TPK	l2sit_tpk	12 items	"Students take part in a live vote using a digital voting system (e.g. Mentimeter)."	Lachner et al., 2019
Beliefs and attitudes				
Teachers' digital competence	l2dce_tl	12 items	"I carefully consider how, when, and why to use digital technologies in class to ensure that they are used with added value."	Lucas et al., 2019; scaling adapted to Antonietti et al., 2022
Self-efficacy for digital teaching	l2seff_digtech	3 items	"I am convinced I can effectively make use of digital learning materials in my courses."	van Acker et al., 2013
Self-efficacy for supporting SRL	l2seff_srl	12 items	"How well can you allow your students to make their own choices about the goals and expectations they set for themselves?"	de Smul et al., 2018
Self-regulation	l2srl	3 items	"What are the challenges for your students when learning with digital media?"	self developed
Teachers' own SRL skills	l2ownsrl	13 items	"I can judge well whether I am on the right track."	Karlen et al., 2024
Teachers' learning strategies	l2mslq_ls	28 items	"I make lists of important items for this course and memorise the lists."	Meijs et al., 2019
Inclusion				
Inclusion awareness	l2incl_awar	12 items	"I change or replace instructional material that could provoke language problems."	adapted from Krüger, 2019; Siwatu, 2007; Rizk & Hillier, 2022
Motivation				
Expectancy-value-cost	l2mot_evc	9 items	"I know that I can effectively put into practice the things presented in this training."	Osman & Warner, 2020

Situation-specific skills				
Situation-specific skills	l2sit_speci	3 items	Scenario analysis: "Please identify the problem."	Wekerle & Kollar, 2021
		3 items	Reflection after the classroom implementation: "What did you notice when implementing new methods in your class?"	Self-developed

5.3 Level 3 – Changes in practices

In level 3, we focus on whether participants have applied the skills and knowledge gained from the training in their professional practice. This is measured to observe changes in practices in a self-report. The table below lists the identifier, constructs, number of items, an example, and the references used in level 3.

Table 7: Variables for evaluating changes in practices (Level 3)

Variable	Identifier	Number of items	Example	Reference
Intended adoption of technology-enhanced learning methods	l3tech_adopt	5 items	"I am using new teaching and learning methods frequently in my teaching practice."	Ley et al., 2022
Technology integration practice	l3tech_integ_p	12 items	To inform about learning objectives and content."	Antonietti et al., 2023
Quality of technology integration	l3lesso_plan	4 items	Lesson plan analysis: "Please describe one prototypical lesson that you taught this week."	Backfisch et al., 2021

5.4 Level 4 – Effect on students' learning

In Level 4, we focus on evaluating the effect of teacher training on student learning outcomes. This involves measuring specific skills and attitudes that are influenced by the teaching practices teachers adopt as a result of their training. An important aspect of this evaluation is that the training content varies across cases. Therefore, it is essential to use items that align with the specific training context, particularly when assessing subject-specific skills. This led to the decision that each case would have its own tailored items. The table below lists the identifier, constructs, number of items, an example, and the references used in Level 4.

Table 8: Variables for evaluating changes in practices (Level 4)

Variable	Identifier	Number of items	Example	Reference
Students' SRL skills	l4stud_srl_cog	13 items	"I can link new information well with what I already know."	Karlen et al., 2024
Students' learning strategies	l2stud_mslq_ls	28 items	"I make lists of important items for this course and memorise the lists."	Meijs et al., 2019
Subject-specific skills	l4subjspec_skil	Each case will use its own items that are adapted to the contents of the lesson(s).		
Subject-specific interest	l4subjspec_int	6 items	"My interest in the subject is high."	Ivanov et al., 2016
Students' digital self-efficacy	l4dig_selfeff	25 items	"search for specific information in digital environments"	Ulfert-Blank & Schmidt, 2022
Students' sense of belonging	l4stud_seb	10 items	"I feel like my ideas count in this class."	Whiting et al., 2018

5.5 Background variables

For each case, studies started with collecting background variables to provide demographic insights about the participants (in-service teachers, pre-service teachers, and students). The table below lists the construct, identifier, number of items, an example, and the references used for the background variables of **in-service and pre-service teachers**.

Table 9: Overview of background variables, school level

Variable	Identifier	Nr of items	Example	Reference
type of school	s_stype	1 item	"In what type of school do you teach?"	self developed
school size	t_size_schol:	1 item	"Approximately how many students are enrolled in your school?"	self developed
teacher staffing	t_teach_staff	1 item	"Approximately how many teachers work at your school?"	self developed
location of school	t_loc_school	1 item	"Is your school located in a rural, suburban, or urban area?"	self developed
technological quality	t_tech_qual	5 items	"How do you judge the computer infrastructure at your school in general?"	Petko et al., 2018
learning management system	t_lms	1 item	"Which learning management system (e.g. Moodle) do you use at your school?"	self developed
school leadership	t_lead_school	7 items	"The school leader gives encouragement and recognition to staff."	Schmitz et al. 2023, Carless et al. 2000
support from school principal	t_princ_sup	3 items	"The principal is well informed about how teachers use digital technology."	Petko et al., 2018
teachers' informal collaboration	t_inform_collab	3 items	"Teachers work in close cooperation when preparing and conducting technology-supported lessons."	Petko et al., 2018
teachers' formal collaboration	t_form_collab1	3 items	"How often do you have school-wide information events	Petko et al., 2018

			related to educational technology?"	
importance of digital technology in school	t_techn_important1	3 items	"The topic "Educational Technology" is of high importance in our school."	Petko et al., 2018

Table 10: Overview of background variables, teacher level

Variable	Identifier	Nr of items	Example	Reference
gender	t_gen	1 item	"Please indicate your gender."	self developed
age	t_age	1 item	"Please indicate your age."	self developed
mother tongue	t_mtongue	1 item	Please indicate your mother tongue."	self developed
teaching qualification	t_qualific	1 item	"Do you have a teaching qualification?"	self developed
level of education	t_degree	1 item	What is the highest level of education you have obtained?"	self developed
teaching subject	t_subjects	1 item	"Which subjects do you teach?"	self developed
training status	t_TrainStatus	1 item	Please indicate in which status you are participating in the training."	self developed
work experience	t_WorkExperience	1 item	"Do you have teaching experience?"	self developed

Table 11: Overview of background variables, student level

Variable	Identifier	Nr of items	Example
Gender	s_gen	1 item	"Please indicate your gender."
Age	s_age	1 item	"Please indicate your age."

Socio-economic background	s_ses	3 items	"Now think about where you would place your family on this scale."
SEN (Special Education Needs)	s_sen	2 items	"Do you have any conditions that may require accommodations or support in your school?"
Migration background and ethnicity	s_mig	2 items	"Do you feel part of the same ethnic group as most people in your country of residence?"
language at home	s_lhome	1 item	"Which language do you speak at home?"

6. Research designs in the pilot phase

6.1 Overview of Research Designs

Table 12: Overview of all treatment conditions and sample size in the pilot phase

Training Conditions	Pre-Service groups (Count)	Pre-Service participants (N)	In-Service groups (Count)	In-Service Participants
KI	3	122	1	15
KI ,CD	4	160	1	15
KI, CD, SL	3	177		
KI, CD, MC	1	43	1	30
SL			1	40
Grand Total	**10**	**449**	**4**	**100**

6.2 Individual Research Designs of the Pilot Phase

Table 13: UWK research design in pilot phase

UWK 1: Mini-MOOC German & EFL Digital			
Experimental conditions		**Sample**	
PK1.1 PK1.2	KI KI + CD	15 15	In-service teachers
DV	1. **Situational TPK** (A, B) 2. **Self-efficacy** of digital teaching (A, B), 3. **Technology integration practices** (A, B), 4. **Quality of technology integration** (D), 5. **Intended adoption** (A, B)		
controls	1. **Training reactions** (B), 2. **Pedagogical pre-training** (A), 3. **Age** (A), 4. **Gender** (A)		
moderator	1. **Teachers' SRL skills** (A)		
Purpose: To test a variation of the training, including collaborative design methods in connection with a MOOC, to pilot an adapted version of the situational TPK test.			

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 14: UWK research design in pilot phase

UWK 2: Internal school training programme + ("SCHILFplus") 1) Digitally on the way through the school year at the primary level 2) Digital skills in practice at secondary level 1			
Experimental Conditions		**Sample**	
PK2.1	SL	40	In-service teachers
DV	1. **Conceptual TPK** (A, B), 2. **Digital competence** (A, B), 3. **Self-efficacy** of digital teaching (A, B), 4. **Technology integration practices** (A, B), 5. **Intended adoption** (A, B)		
controls	1. **Training reactions** (B), 2. **Age**, 3. **Gender**, 4. **Pedagogical pre-training**, 5. **Participation in training** (voluntary vs. mandatory)		
moderator	1. **Importance of digital technology in school** (A), 2. **Support from school principal** (A)		
Purpose: To pilot the EffecTive intervention approach within an Austrian internal school training programme and integrate three parts of situated learning (instruction, implementation in the classroom, reflection)			

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 15: UULM research design in pilot phase

UULM 1: Modul Digital Teaching			
Experimental Conditions		**Sample**	
PU1.1	KI + CD	30	Pre-service teachers
DV	1. **Cognitive load** (B), 2. Teachers' **SRL skills** (A, B), 3. **Expectancy-value-cost** (A, B), 4. **Self-efficacy** (A, B), 5. **Teachers' learning strategies** (A, B)		
moderator	1. Teachers' **SRL skills**, 2. **Expectancy-value-cost**, 3. **Self-efficacy**		
Purpose: To test differences in SRL, motivation and perceived load in two groups that are being trained directly and indirectly in SRL strategies.			

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 16: UULM research design in pilot phase

UULM 2: Modul Digital Teaching and Learning and Self-regulated Learning			
Experimental Conditions		**Sample**	
PU1.2	KI + CD + MC	30	Psychologists
DV	1. **Cognitive load** (B), 2. Teachers' **SRL skills** (A, B), 3. **Expectancy- value-cost** (A, B), 4. **Self-efficacy** (A, B), 5. **Teachers' learning strategies** (A, B)		
moderator	1. Teachers' **SRL skills**, 2. **Expectancy- value-cost**, 3. **Self-efficacy**		
Purpose: To test differences in SRL, motivation and perceived load in two groups that are being trained directly and indirectly in SRL strategies.			

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 17: TAU research design in pilot phase

TAU: Digital Pedagogy 2.0: Promoting Independent Learners			
Experimental Conditions		**Sample**	
PI1.1 PI1.2	KI KI + CD	37 24	Pre-service teachers
DV	**1. Situation-specific skills** (B), **2. Intended Adoption** (Perception of chatbots for teaching) (A,B), **3. Technology-integration practices** (B)		
moderator	**1. Teachers' SRL skills** (A,B)		
Purpose	To test the effect of teaching methods (KI and CD) in the form of a course for teachers on SRL skills		

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 18: TLU research design in pilot phase

TLU : Pre-service teachers introductory Technology-enhanced learning course			
Experimental Conditions		**Sample**	
PT1.1 PT1.2 PT1.3 PT1.4	KI+CD KI+CD+SL KI KI	76 30 60 25	Pre-service teachers

DV	1. **Knowledge** (A, B). 2. **Digital competence** (A, B), 3. **Self-efficacy** of digital tools / supporting SRL (A, B) 4. **Situation-specific skills** (A, B, D), 5. **Technology-integration practices** (A, B, D) 6. **Intended adoption** (A, B)
controls	1. **Training reactions** (B), 2. **Study program** (A), 3. **Age** (A), 4. **Gender** (A) 5. **Working experience** (A)
moderator	1.Teachers' **SRL skills** (A)
Purpose	To test teaching methods in different settings (online, face-to-face, domain-specific, general course) for teachers' development of situation-specific skills

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 19: UAU research design in pilot phase

UAU 1: Course for trainee teachers on digital skills			
Experimental Conditions		**Sample**	
PA1.1 PA1.2	KI+CD+SL KI + CD	17 30	Pre-service teachers
DV	1. **Digital competence** (A, B) 2. **Situation-specific skills** (A, B, D). 3. **Intended adoption** (B), 4. **Knowledge** (B). 5. **Self-efficacy** of digital tools / supporting SRL (A, B) 6. **Technology-integration practices** (D), 7. **Training reactions** (B), 8. **Inclusion awareness** (A, B), 9. **Perceived-task-value** (B)		
control	1. **Knowledge** (A)		
moderator	1.Teachers' **SRL skills** (A), 2. **Digital competence** (A)		
Purpose: To test the effect of teaching methods (KI, CD and SL) in the form of a course for trainee teachers on digital competence			

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 20: UOULU research design in pilot phase

UOULU 1: Introduction to Technology-Supported Learning and Working Course			
Experimental Conditions		**Sample**	
PO1.1	KI+CD+SL	113	Pre-service teachers

DV	1. **Digital competence** (A, B), 2. **Intended adoption** (B), 3. **Knowledge** (A, B), 4. **Self-efficacy** for digital teaching/ supporting SRL (A, B), 5. **Technology-integration practices** (D), 6. **Training reactions** (B), 7. **Expectancy- value-cost beliefs** (A, B), 8. **SRL skills** (A)
control	1. **Training reactions** (B), 2. **Study program** (A), 3. **Age** (A), 4. **Gender** (A) 5. **Teaching experience** (A)
moderator	1.Teachers' **SRL skills** (A), 2. **Expectancy-value-cost beliefs** (A, B),
Purpose: To test the training effect on digital competence and knowledge among pre-service teachers with varying levels of motivational beliefs, and SRL skills.	

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

7. Research designs in the intervention phase

7.1 Overview of research designs

The intervention phase (M12-M24) of the EffecTive project aims to test the hypotheses H1-H3 as described in Section 3. This phase implements and evaluates various training methods to assess their impact on pre-service and in-service teachers' PDC—focusing on their knowledge, skills, and attitudes toward integrating learning technologies into teaching and learning. Additionally, the interventions address changes in practices and motivational factors influencing the adoption of new practices.

This phase also examines the effects on students, particularly their development of SRL skills and subject-specific skills. In this section the research designs employed are outlined as guiding principles for the intervention phase.

Table 21: Overview of treatment conditions and sample sizes for the intervention phase

Training Conditions	Sum of preservice groups	Sum of preservice N	Sum of inservice groups	Sum of inservice N	Sum of student N
KI	2	52	5	117	550
KI ,CD	1	22	2	40	350
KI, CD, SL	1	65	2	45	550
KI, CD, SL, MC	1	65			
KI, CD, MC			1	30	300
KI, SL	1	24	7	187	960
KI, SL, MC			3	79	460
Control	1	24	9	183	1230
Grand Total	**7**	**252**	**29**	**681**	**4400**

7.2 Individual research designs

Table 22: UWK research design in the intervention phase

UWK 1: Learn to think, solve problems with digi.case: Massive Open Online Course (MOOC) + face-to-face training					
	Conditions	**Teacher sample** (N)	Type	**Student Sample** (N)	Type
CK1.1 CK1.2 CK1.0	KI KI + CD Waiting control group	20 20 20	Primary school In-service	100 100 100	Primary school students
DV	1. **Conceptual TPK** (A, B), 2. **Digital competence** (A, B), 3. **Self-efficacy** of digital teaching, 4. **Situation-specific skills** (D), 5. **Intended adoption** (A, B), 7. **Technology integration practices** (A, B), 8. **Quality of technology integration** (D), 9. **Students' digital competence** (C, E), 10. Students' **subject-specific skills** (C, E)				
control	1. **Training quality** (B), 2. **Gender** (A), 3. **Age** (A), 4. Students' **socio-economic background** (A), 5. Students' **subject-specific interest** (A)				
moderator	1. **Self-efficacy** of digital teaching (A), **Student's SRL skills** (C, E)				
mediator	1. **Situation-specific skills** (D), **2. Expectancy-value-cost** (B)				
Hypotheses: ***H1.1***: KI methods are expected to enhance teachers' technological pedagogical knowledge by increasing their cognitive understanding of key concepts, such as self-regulated learning and cognitive engagement. (main hypothesis 1) ***H1.2***: CD methods are expected to enhance teachers' complex knowledge and skills and self-efficacy by promoting the co-design of teaching strategies through peer collaboration. (main hypothesis 1) ***H2.1***: The inclusion of Collaborative Design (CD) will increase the perceived value and teachers' intentions to adopt technology-enhanced learning methods in their classroom teaching. (main hypothesis 2) **H2.3:** Training leads to improved classroom practices and enhances student learning outcomes in terms of subject-specific skills. (main hypothesis 2)					

* *Note:* The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 23: UWK research design in the intervention phase

UWK2: Internal school training series (SCHILF/SCHÜLF) organised by KPH Vienna/Lower Austria in the area of Digital Education/Media Education					
	Conditions	**Teacher sample** (N)	Type	**Student Sample** (N)	Type
CK2.1 CK2.2 CK2.3 CK2.0	KI KI + SL KI + SL + MC Parallel non-training control group	25 25 25 25	Secondary school In-service	150 150 150 150	Secondary school students
DV	1. **Situational TPK** (A, B), 2. **Self-efficacy** of digital teaching, 3. **SRL skills** (A), 4. Technology integration practices (A, B), 5. **Intended adoption** (A, B), 6. **Quality of technology integration** (D), 7. Students' **digital competence** (C, E), 8. Students' **subject-specific skills** (C, E)				
control	1. **Training quality** (B), 2. Students' **subject-specific interest** (C, E), 5.				
moderator	1. **Self-efficacy** of digital teaching (A), **Student's SRL skills** (C, E)				
med	1. **Situation-specific skills** (D), 2. **Expectancy-value-cost** (B)				
Hypotheses: **H1.1**: KI methods are expected to enhance teachers' pedagogical and technological knowledge by increasing their cognitive understanding of key concepts, such as self-regulated learning and cognitive engagement. (main hypothesis 1) **H1.3**: SL methods are expected to develop teachers' situation-specific skills, leading to stronger intentions to adopt new practices by emphasising the perceived value of these methods over their associated costs. (main hypothesis 1) **H1.4**: Mentoring is expected to enhance teachers' attitudes and support the practical application of new methods, leading to stronger adoption intentions by providing ongoing guidance to overcome challenges and apply training in classrooms. (main hypothesis 1) ***H2.1***: The inclusion of Collaborative Design (CD), Situated Learning (SL) and Mentoring (MC) will increase the perceived value and teachers' intentions to adopt technology-enhanced learning methods in their classroom teaching. (main hypothesis 2) **H2.3**: Training leads to improved classroom practices and enhances student learning outcomes in terms of subject-specific skills. (main hypothesis 2)					

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 24: UULM research design in the intervention phase

UULM1: Nugget Digi 2					
	Conditions	**Teacher sample** (N)	Type	**Student Sample** (N)	Type
CU1.1 CU1.2 CU1.0	KI KI + SL Waiting control group	24 24 24	In-service		
DV	1. **Intended adoption** (A, B), 2. **Knowledge** (A, B), 3. **Technology-integration practices** (A, B), 4. **Training reactions** (B), 5. **Cognitive Load (load & effort)** (B), 6. **Expectancy-value-cost** (A, B), 7. **Self-efficacy** of digital tools (A, B)				
control	1. **Conceptual TPK** (A)				
moderator	1. Teachers' **SRL skills** (A), 2. **Teaching experience**				
Hypotheses: **H1.1**: KI methods are expected to enhance teachers' pedagogical and technological knowledge by increasing their cognitive understanding of key concepts, such as self-regulated learning and cognitive engagement. (main hypothesis 1) **H1.3**: SL methods are expected to develop teachers' situation-specific skills, leading to stronger intentions to adopt new practices by emphasising the perceived value of these methods over their associated costs. Additionally we expect SL methods to increase mental effort and reduce cognitive load. (main hypothesis 1) ***H2.1***: The inclusion of Situated Learning (SL) will increase the perceived value and teachers' intentions to adopt technology-enhanced learning methods in their classroom teaching. (main hypothesis 2)					

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 25: UULM research design in the intervention phase

UULM2: DLL SAPS					
	Conditions	**Teacher sample** (N)	Type	**Student Sample** (N)	Type
CU2.1 CU2.2 CU2.0	KI KI + SL alternative training control group	23 29 20	In-service		

DV	1. **Intended adoption** (A, B), 2. **Situational TPK** (B), 3. **Technology-integration practices** (A, B), 4. **Training reactions** (B) 5. **Cognitive Load (load & effort)** (B), 6. **Expectancy-value-cost** (A, B), 7. **Self-efficacy** of digital tools (A, B)
control	1. **Conceptual TPK** (A)
moderator	1. Teachers' **SRL skills** (A), 2. **Teaching experience**
Hypotheses: **H1.1**: KI methods are expected to enhance teachers' pedagogical and technological knowledge by increasing their cognitive understanding of key concepts, such as self-regulated learning and cognitive engagement. (main hypothesis 1) **H1.3**: SL methods are expected to develop teachers' situation-specific skills, leading to stronger intentions to adopt new practices by emphasising the perceived value of these methods over their associated costs. Additionally we expect SL methods to increase mental effort and reduce cognitive load. (main hypothesis 1) ***H2.1****:* The inclusion of Situated Learning (SL) will increase the perceived value and teachers' intentions to adopt technology-enhanced learning methods in their classroom teaching. (main hypothesis 2)	

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 26: UULM research design in the intervention phase

UULM3: Nugget SRL					
	Conditions	**Teacher sample** (N)	Type	**Student Sample** (N)	Type
CU3.1 CU3.2 CU3.0	KI + SL KI + SL + MC Parallel non-training control group	24 24 24	Secondary school In-service	60 60 30	Secondary school students
DV	1. **Intended adoption** (A, B), 2. **Situational TPK** (B), 3. **Technology-integration practices** (A, B), 4. **Training reactions** (B) 5. **Cognitive Load** (B, D), 6. **Expectancy-value-cost** (A, B), 7. **Self-efficacy** of digital tools (A, B), 8. Students' **SRL skills** (C, E), 9. Students' **Self-efficacy** (C, E), 10. Students' **Cognitive Load** (E), 11. Students' **specific skills** (C, E)				
control	1. **Conceptual TPK** (A)				
moderator	1. Teachers' **SRL skills** (A), 2. **Teaching experience,** 3. Student **SRL** (C)				
med	1. Teachers' **self efficacy** (B), 2. Teachers **cognitive load** (Load & effort) (B), 3. Students' **cognitive load** (load & effort) (E)				

Hypotheses: **H1.1**: KI methods are expected to enhance teachers' pedagogical and technological knowledge by increasing their cognitive understanding of key concepts, such as self-regulated learning and cognitive engagement. (main hypothesis 1) **H1.3**: SL methods are expected to develop teachers' situation-specific skills, leading to stronger intentions to adopt new practices by emphasising the perceived value of these methods over their associated costs. Additionally we expect SL methods to increase mental effort and reduce cognitive load. (main hypothesis 1) ***H2.1**:* The inclusion of Mentoring Coaching (MC) will increase the perceived value and teachers' intentions to adopt technology-enhanced learning methods in their classroom teaching. (main hypothesis 2) ***H2.2***: The inclusion of Mentoring Coaching (MC will enhance technology-enhanced teaching practices in classrooms, mediated by teachers' self-efficacy and cognitive load. (main hypothesis 2) ***H2.3***: Training including MC leads to improved classroom practices and enhances student learning outcomes in terms of subject-specific skills. (main hypothesis 2) ***H2.4***: Training including MC leads to teachers' SRL self-efficacy beliefs and SRL practices (lesson plans, …) leading to students' improved SRL skills. (main hypothesis 2) **H3:** The inclusion of Situated Learning (SL) will lower the achievement gaps (i.e. inequity) in student learning outcomes (e.g., fewer heterogeneous treatment effects in student outcomes). **H3.1:** Students' SRL moderate the effect of TEL practices on achievement gaps (main hypothesis 3) **H3.2:** Students' Cognitive Load and effort mediate the effect of TEL practices on achievement gaps (main hypothesis 3)

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 27: UULM research design in the intervention phase

UULM4: DLL Uni					
	Conditions	**Teacher sample** (N)	Type	**Student Sample** (N)	Type
CU4.1 CU4.2 CU4.0	KI KI + SL Parallel non-training control group	24 24 24	Pre-service		
DV	1. **Intended adoption** (A, B), 2. **Cognitive Load** (B), 3. **Expectancy-value-cost**(A, B), 4. **Self-efficacy** of digital tools (A, B), 1. **Situational TPK** (B). 2. **Technology-integration practices** (A, B), 4. **Training reactions** (B)				
control	1 .**Conceptual TPK** (A)				

moderator	1. Teachers' **SRL skills** (A), 2. **Teaching experience**
Hypotheses: **H1.1**: KI methods are expected to enhance teachers' pedagogical and technological knowledge by increasing their cognitive understanding of key concepts, such as self-regulated learning and cognitive engagement. (main hypothesis 1) **H1.3**: SL methods are expected to develop teachers' situation-specific skills, leading to stronger intentions to adopt new practices by emphasising the perceived value of these methods over their associated costs. Additionally we expect SL methods to increase mental effort and reduce cognitive load. (main hypothesis 1)	

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 28: TAU research design in the intervention phase

TAU1: Digital Pedagogy 2.0: Promoting Independent Learners					
	Conditions	**Teacher sample** (N)	Type	**Student Sample** (N)	Type
CI1.1 CI1.2	KI KI + CD	28 22	Pre-service		
DV	1. **Conceptual** and **Situational TPK** (A, B), 2. **Situation specific skills** (A, B), 3. **Self-efficacy** for digital teacher/for supporting SRL (A, B), 3. **Intended adoption** (A, B), 4. **Technology-integration practices** (A, B),				
controls	**Training reactions** (B)				
moderator	**Teachers' SRL skills** (A, B)				
med					
Hypotheses: **H1.1:** KI methods are expected to enhance teachers' pedagogical and technological knowledge by increasing their cognitive understanding of key concepts, such as self-regulated learning and cognitive engagement. (main hypothesis 1) **H1.2:** CD methods are expected to enhance teachers' complex knowledge and skills and self-efficacy by promoting co-design of teaching strategies through peer collaboration. (main hypothesis 1)					

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 29: TAU research design in the intervention phase

<table>
<tr><th colspan="6">TAU2: Engaging with AI: Leveraging a Generative AI (Gen-AI) Chatbot to Enhance Self-Regulated Learning</th></tr>
<tr><td></td><td>Conditions</td><td>Teacher sample (N)</td><td>Type</td><td>Student Sample (N)</td><td>Type</td></tr>
<tr><td>CI2.1
CI2.2
CI2.0</td><td>KI + CD
KI + CD + SL
Parallel non-training control group</td><td>20
20
10</td><td>Secondary school Education In-service</td><td>-
250
250</td><td>Secondary school students</td></tr>
<tr><td>DV</td><td colspan="5">1. Conceptual and Situational TPK (A, B), 2. Situation specific skills (A, B), 3. Self-efficacy for digital teacher/for supporting SRL (A, B), 3. Intended adoption (A, B), 4. Technology-integration practices (A, B), 5. Subjects' specific skills (A, B), 6. Students' digital competences (C, E), 7. Students' SRL skills (C, E)</td></tr>
<tr><td>control</td><td colspan="5">Training reactions (B)</td></tr>
<tr><td>moderator</td><td colspan="5">Teachers' SRL skills (A)</td></tr>
<tr><td>med</td><td colspan="5"></td></tr>
<tr><td colspan="6">Hypotheses:
H1.1: KI methods are expected to enhance teachers' pedagogical and technological knowledge by increasing their cognitive understanding of key concepts, such as self-regulated learning and cognitive engagement. (main hypothesis 1)
H1.2: CD methods are expected to enhance teachers' complex knowledge and skills and self-efficacy by promoting co-design of teaching strategies through peer collaboration. (main hypothesis 1)
H2.1: The inclusion of Collaborative Design (CD) and Situated Learning (SL) will increase the perceived value and teachers' intentions to adopt technology-enhanced learning methods in their classroom teaching. (main hypothesis 2)
H2.2: The inclusion of Situated Learning (SL) will enhance technology-enhanced teaching practices in classrooms, mediated by teachers' self-regulated learning skills. (main hypothesis 1)
H2.3: Training leads to improved classroom practices and enhances student learning outcomes in terms of subject-specific skills. (main hypothesis 2)
H2.4: Training leads to teachers' SRL self-efficacy beliefs and SRL practices (lesson plans, …) leading to students' improved SRL skills. (main hypothesis 2)</td></tr>
</table>

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 30: TLU research design in the intervention phase

TLU case2: Teachers' in-service training on pedagogical digital competence in mathematics					
	Conditions	**Teacher sample** (N)	Type	**Student sample** (N)	Type
CT1.1 CT1.0	KI + SL Parallel non-training control group	25 20	Primary school teachers	200 200	Primary school students
DV	1. **Knowledge** (A, B). 2. **Digital competence** (A, B), 3. **Self-efficacy** of digital tools / supporting SRL (A, B) 4. **Situation-specific skills** (A, B, D), 5. **Technology-integration practices** (A, B, D) 6. **Intended adoption** (A, B) 7. Students' **subject-specific skills** (C, E).				
control	1. **Prior job experience** (A), 2. Training **reactions** (B),				
mod	1. Teacher **SRL skills** (A), 2. **Student's SRL skills** (C),				
Hypotheses **1. H1.1: KI+SL** training method has a positive effect on teachers' **digital competence** (*Global hypothesis 1*) and **intended adoption** of new practices in their teaching (main hypothesis 2) **2. H1.2: KI+SL** training method improves teachers' **situation-specific skills** in mathematics (main hypothesis *1)* ***3. H2.1:* KI+SL** training method positively impact students' **subject-specific skills** (main hypothesis 2)					

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 31: TLU research design in the intervention phase

TLU case2: Whole-school intervention to develop teachers PDC in culturally diverse settings					
	Conditions	**Teacher sample** (N)	Type	**Student sample** (N)	Type
CT2.1 CT2.2 CT2.0	KI+SL KI+SL+MC Parallel non-training control group	30 30 20	Primary school teachers	250 250 250	Primary school students
DV	1. **Knowledge** (A, B). 2. **Digital competence** (A, B), 3. **Self-efficacy** of digital tools / supporting SRL (A, B) 4. **Situation-specific skills** (A, B, D), 5. **Technology-integration practices** (A, B, D) 6. **Intended adoption** (A, B) 7. Students' **subject-specific skills** (C, E).				
control	1. **Organisational** variables (A), 2. **Students' demographic variable** (c). 3. Teachers' **prior job experience** (A) 4. Training **reactions** (B),				

mod	1. Teacher **SRL skills** (A), 2. **Student's SRL skills** (C),
Hypotheses **H1.2: KI+SL** and **KI+SL+MC** training approaches improve teachers' **situation-specific skills**, such as observing, interpreting, and making decisions about classroom situations involving technology integration (main hypothesis 1) **H2.1: KI+SL** and **KI+SL+MC** trainings have a positive effect on teachers' **digital competence** (main hypothesis 1) and teachers' **intended adoption** of digital tools and practices in their teaching (main hypothesis 2) **H2.2: KI+SL** and **KI+SL+MC trainings** will increase the perceived value and teachers' intentions to adopt technology-enhanced learning methods in their classroom teaching. (main hypothesis 2) **H3.1**: **KI+SL** and **KI+SL+M** training approaches positively impact students' **subject-specific skills, moderated by equity and inclusion factors**	

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 32: UAU research design in the intervention phase

UAU: school intervention					
	Conditions	**Teacher sample** (N)	Type	**Student sample** (N)	Type
CA1.1 CA1.2 CA1.0	KI + SL KI + CD + MC Parallel non-training control group	30 30 20	Secondary school teachers	300 300 250	Secondary school students
DV	1. **Intended adoption** (A, B), 2. **Subjects' specific skills** (A, B), 3. Students' **digital competences** (C, E), 4. Students' **specific skills** (C, E), 5. **Conceptual TPK** (A, B), 6. **Technology-integration practices** (A, B), 7. **Self-efficacy** for digital teacher/for supporting SRL (A, B), 8. **Training reactions** (A, B), 9. Students' **SRL** (C, E)				
control					
moderator	1. Teachers' **SRL skills** (A), 2. **Teacher qualification**, 3. **School environment**				
med	1. **Conceptual TPK,** 2. **Inclusion awareness**				

Hypotheses:
H1.1: Training effects on teachers' PDC: The training positively affects teachers' satisfaction with the course, situation-specific skills, knowledge, self-efficacy, and perceived digital competence, with stronger effects for those with higher SRL skills. (main hypothesis 1)
H2.1: .Training effects on classroom practices: The training enhances teachers' adoption of technology in the classroom and their perception of value, leading to increased TPK. (main hypothesis 2)
H2.2: Effects on students' learning: Improvements in teachers' knowledge, skills, and attitudes enhance student learning outcomes by fostering students' SRL skills and reducing inequities in TEL environments. (main hypothesis 2)

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 33: UOULU research design in the intervention phase

UOULU1: pre-service teachers					
	Conditions	**Teacher sample** (N)	Type	**Student sample** (N)	Type
CO1.1 CO1.2	KI + CD + SL KI + CD + SL + MC	65 65	Pre-service		
DV	1. **Intended adoption**, 2. **Subjects' specific skills**, 3. D**igital competences,** 4. **Knowledge,** 5. **Technology-integration practices**, 6. **Self-efficacy** for digital teaching, 7. **Training reactions**				
control	1. **Training reactions**, 2. **Demographics**				
moderator	1. Teachers' **SRL skills**, 2. **Teacher experience**, 3. **Motivation, 4. Digital competences**				
med					

Hypotheses:
H1.1: Training effects on teachers' PDC: The training positively affects pre-service teachers' satisfaction with the course, situation-specific skills, TPACK, self-efficacy for digital teaching, and perceived digital competence, with stronger effects for those who have higher SRL skills. (main hypothesis 1)
H1.2: Training effects on classroom practices: The training enhances pre-service teachers' adoption of technology in the classroom and their perception of value, leading to increased TPK, TK, and PK. (main hypothesis 1)

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

Table 34: UOULU research design in the intervention phase

UOULU2: in-service teachers (to be confirmed)					
	Conditions	**Teacher sample** (N)	Type	**Student sample** (N)	Type
CO2.1 CO2.2	KI + CD + SL KI	25 25	In-service	300 300	
DV	1. **Intended adoption** (B), 2. **Subjects' specific skills** (A,C), 3. **Digital competences (A, B,C)**, 4. **Knowledge** (A, B), 5. **Technology-integration practices** (B, E), 6. **Self-efficacy** for digital teaching (A, B), 7. **Training reactions** (B), **8. SRL skills** (A, B, C, E), 9. **Expectancy-value-cost** beliefs (A, B).				
control	1. Prior **teaching experience,** 2. **Prior training**, 3. **Training reactions**, 4. **School environment**				
moderator	1. **Teachers' SRL skills**, 2. **Teacher experience, 4. Digital competences,** 5. **Students' SRL skills** 6. Student **subject-specific knowledge**				
med					
Hypothesis: ***H1.1***: The higher the training complexity, the higher influence on teachers' TPK. (main hypothesis 1) ***H1.2***: CD is expected to enhance teachers' TPACK, self-efficacy to promote SRL, and self-efficacy for digital teaching through group work activities where teachers co-construct their TPACK. (main hypothesis 1) ***H1.3***: CD is expected to contribute to teachers' expectancy, value and cost beliefs related to technology implementation in the classroom. (main hypothesis 1) ***H2.1***: CD and SL will increase teachers' intentions to adopt TEL methods. (main hypothesis 2) ***H.2.2***: CD and SL will increase teachers' situation specific skills related to technology implementation in the classroom. (main hypothesis 2) ***H.2.3***: Training is expected to increase teachers' self-efficacy for digital teaching which will improve students' digital competence (main hypothesis 2) ***H.2.4***: Training is expected to increase teachers' self-efficacy to promote SRL in the classroom which will result in higher SRL skills among students. (main hypothesis 2)					

* *Note*. The EffecTive project employs a pre-post-test design with multiple measurement points (A: Teacher pre-test; B: Teacher post-test; C: Student pre-test; D: Teacher Implementation Check; E: Student post-test)

8. Conclusions and outlook

The current report outlines a multi-site quasi-experimental research design using a pre-test and post-test approach, implemented simultaneously in five different countries. This design is applied across diverse teacher training contexts (both pre-service and in-service) and is aligned with various national policy measures, reflecting the significant differences between these contexts. The challenge was to develop a robust and rigorous methodology that would still be sensitive to the local and national conditions. This required an intense process of top down planning and guidance as well as bottom-up experience sharing and adaptation. The flexible, highly participatory and iterative approach the project followed throughout the first year was instrumental for successfully establishing this plan.

The pilot phase provided valuable insights into **refining instruments, adapting items for specific groups**, and optimising data collection processes to better capture the complex dynamics of teacher and student development. The experience highlighted the need to address several key areas, such as **streamlining data collection instruments to reduce their length** and **improve participant engagement**, **enhancing communication** about the purpose and process of data collection, and **ensuring the contextualisation** and translation of instruments to align with the diverse cultural and educational environments. These adjustments aim to balance the depth of information gathered with the practical constraints faced by participants, particularly pre-service teachers, whose needs necessitated tailored adaptations to the instruments.

Additionally, the pilot underscored the value of incorporating **process-oriented data collection methods**, such as real-time logging or reflective journals, to complement self-reported instruments and provide richer insights into engagement over time. Careful attention was also given to the **design of control groups**, ensuring that counterfactuals accounted for the complexity of the treatment design. Efforts were made to mitigate potential biases, such as those arising from self-selection into the treatment, by matching key variables like teaching experience and educational context to enhance the validity and comparability of findings. These refinements set a good foundation for a thorough evaluation of the effects of the interventions.

This research design and plan is a highly ambitious and innovative approach. To the best of the research team's knowledge, similar efforts have been rare or not extensively documented in previous studies evaluating teacher training programs. It builds the foundation for the data analysis strategy which will be further developed in the upcoming months. Establishing a robust, ethically grounded, and systematically organised data analysis process is crucial for the evaluation in the EffecTive project. The unified approach to data management, from pre-registration and data screening to secure storage and anonymisation, ensures data integrity and participant privacy. Each step in the data collection and analysis workflow - from instrument selection to coding and integration - has been designed to maintain consistency and accuracy across datasets, thereby allowing cooperation between institutions in data analysis, pooling datasets, and interpretation of effect sizes.

This deliverable is closely complemented by **D6.2 (Ethics Plan)**, and **D7.1 (Ethics Requirements)**, which provides the regulatory framework for ethical compliance and ensures that ethical considerations are embedded throughout the study, and **D6.3 (Data Management Plan)**, which outlines procedures for data storage, access, and security. Together, these documents support an ethical and transparent approach, ensuring the reliability of findings.

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