

Impact of In-Service Digital Pedagogy Training on Classroom Practices

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Abstract— The rapid digitalisation of school systems worldwide has placed new demands on teachers to integrate digital tools meaningfully into everyday instruction. In-service digital pedagogy training has emerged as a principal policy lever for building this capacity, yet questions remain about whether such training translates into sustained changes in classroom practice rather than superficial technology use. This paper presents a systematic review and conceptual synthesis of empirical and theoretical literature on the impact of in-service digital pedagogy training on classroom practices. Drawing on the Technological Pedagogical Content Knowledge (TPACK) framework, Ertmer's first- and second-order barriers model, and Desimone's core-features framework for effective professional development, the review synthesises findings from peer-reviewed studies published between 1999 and 2025. The synthesis indicates that well-designed, sustained, and collaborative training programmes reliably improve teachers' digital self-efficacy and technology-related beliefs, and that these gains are associated with more frequent and more pedagogically purposeful use of digital tools in the classroom. However, the translation of training into practice is uneven, moderated by teachers' prior confidence, school-level infrastructure, leadership support, and the extent to which training is content-focused rather than merely technical. The paper concludes that digital pedagogy training is necessary but not sufficient for

classroom transformation, and that policy and institutional support structures must accompany training for durable pedagogical change to occur.

Keywords— *in-service training, digital pedagogy, classroom practice, teacher professional development, TPACK, technology integration*

Introduction

Digital technologies have become deeply embedded in the infrastructure of contemporary schooling, reshaping expectations of what teaching and learning should look like in the twenty-first century. Learning management systems, digital assessment tools, interactive whiteboards, and increasingly, artificial intelligence applications, are no longer peripheral additions to the classroom but are treated by many education systems as core instructional resources. This shift has been accelerated by large-scale disruptions such as the COVID-19 pandemic, which compelled teachers across the globe to rapidly adopt online and blended modes of instruction, often without adequate preparation (Reher et al., 2025). In this context, in-service digital pedagogy training, professional development delivered to practising teachers with the explicit aim of building the knowledge, skills, and confidence needed to integrate digital tools pedagogically, has assumed central importance in education policy.



The premise underlying such training is straightforward: if teachers are equipped with digital competencies and pedagogical models for using them, their classroom practices will shift towards more technology-enriched, learner-centred, and differentiated instruction. Yet the relationship between training and practice is considerably more complex than this premise suggests. Teachers do not simply absorb new skills and immediately transfer them into daily instruction; rather, the enactment of digital pedagogy is shaped by an interplay of personal beliefs, institutional conditions, curricular pressures, and the design quality of the training itself (Ertmer, 1999). Some teachers who complete extensive training continue to use digital tools only for administrative or presentational purposes, while others transform their pedagogy substantively, redesigning assessment, feedback, and student engagement strategies around digital affordances.

This paper addresses this gap by systematically reviewing recent empirical and theoretical literature examining the impact of in-service digital pedagogy training on classroom practices. It seeks to identify the mechanisms through which training influences practice, the conditions under which this influence is strongest, and the barriers that most frequently prevent training from being translated into sustained pedagogical change. The paper is structured as follows: first, a review of the theoretical and empirical literature is presented, organised around key thematic strands; second, the theoretical framework guiding the synthesis is outlined; third, the review methodology is described; fourth, the findings emerging from the synthesis are presented; and finally, the implications of these findings are discussed, followed by concluding recommendations for policy and practice.

Literature Review

Digital Pedagogy and the Rationale for In-Service Training

Digital pedagogy refers to the deliberate, theoretically grounded use of digital technologies to support teaching and learning, as distinct from the mere presence of technology in classrooms. Bentri and Hidayati (2023) reported that in-service training focused on a structured digital pedagogy curriculum produced measurable gains in teacher competence among elementary school teachers, and argued that in-service training allows teachers to develop these competencies without withdrawing entirely from their classroom responsibilities. This reflects a broader consensus in the literature that professional development is the primary vehicle through which practising teachers, who did not receive extensive digital pedagogy preparation during their initial training, can acquire the competencies needed for the digital classroom. A systematic review by Osorio Vanegas et al. (2025) identified seven key

competencies that in-service teachers need to develop to integrate educational technology effectively into their pedagogical practice, drawn from an analysis of eighty-two studies, and noted that research in this area is concentrated in regions with high levels of technological infrastructure, including Europe, Asia, and North America.

Empirical Evidence on the Effects of Training

Several recent empirical studies provide direct evidence on how in-service digital pedagogy training affects teachers. In a Finnish study conducted as part of the OpenDigi initiative, Pongsakdi et al. (2021) investigated the impact of digital pedagogy training on ninety-eight elementary and lower-secondary in-service teachers, with a subsample of twenty-two teachers completing both pre- and post-training measures. Their results showed that the impact of training was moderated by teachers' pre-existing ICT confidence: teachers with low initial confidence exhibited significant increases in ICT confidence following training, whereas teachers who already had high confidence showed no significant additional change. This finding is important because it suggests that the benefits of in-service training are not uniform across a teaching population and that training designed without attention to teachers' starting points may under-serve more confident teachers while over-serving as a baseline intervention for less confident ones.

In a larger-scale German study, Reher et al. (2025) examined the effects of eight discipline-specific STEM in-service teacher training programmes, developed in collaboration with university-based out-of-school student laboratories, on the professional knowledge, self-efficacy, and technology commitment of one hundred and five STEM teachers. Using a pre-post-test design, the study found that these trainings had positive overall effects on teachers' self-assessed professional knowledge and their self-efficacy for using subject-specific digital media, supporting the argument that partnerships between schools and external expert institutions can strengthen the practical relevance of in-service training.

Complementing these findings, a large mixed-methods study conducted in China by Shi et al. (2025) surveyed four hundred and seventy-eight teachers and found that digital pedagogy competence significantly predicted increased work engagement and reduced emotional exhaustion, with this relationship operating through teachers' digital self-efficacy. The study, situated within the post-pandemic push for inclusive digital pedagogy, also tested a two-week TPack-based professional development intervention with sixty teachers randomly assigned to intervention and control groups, reporting favourable effects on teacher competence, self-efficacy, and occupational well-being, suggesting that the benefits of in-service digital pedagogy training may extend beyond

instructional practice into teachers' psychological experience of their work.

Not all evidence is confined to in-service teachers narrowly defined. A related strand of research on digital training courses designed for both pre-service and in-service biology teachers found that an asynchronous, modular online course, grounded in the Theory of Planned Behaviour and the TPACK framework, strengthened participants' behavioural intentions to implement digital instructional scaffolds in their teaching, indicating that structured digital training can shift not only competence but also teachers' intentions to enact new practices in the classroom (Offermann et al., 2025).

Barriers to Translating Training into Classroom Practice

Despite consistent evidence that in-service training can improve teachers' digital competence, confidence, and intentions, a parallel body of literature cautions that these gains do not automatically translate into changed classroom practice. Ertmer's (1999) foundational distinction between first-order and second-order barriers to technology integration remains one of the most widely used frameworks for explaining this gap. First-order barriers are external to the teacher, encompassing inadequate access to hardware and software, insufficient time for planning and practice, and a lack of technical or institutional support. Second-order barriers are internal, encompassing teachers' pedagogical beliefs, their confidence in using technology, and their willingness to change established routines. Ertmer argued that training programmes historically focused on overcoming first-order barriers, such as basic technical skills, while paying insufficient attention to the deeper pedagogical beliefs that determine whether teachers actually integrate technology meaningfully into instruction.

Subsequent research has reinforced and extended this framework. Abedi and Ackah-Jnr (2023), examining technology integration in a resource-constrained setting in Ghana, found that first-order barriers, including limited technological resources, weak leadership support, and inconsistent access to professional development, were perceived by teachers as having a more significant impact on their practice than second-order barriers, challenging the assumption that internal beliefs are always the dominant obstacle. Tawfik et al. (2021), examining the sudden shift to emergency online teaching during the COVID-19 pandemic, found that time constraints for training and lesson redesign, alongside technical and administrative support gaps, were central first-order barriers that undermined teachers' ability to apply newly acquired digital pedagogy skills in practice. Together, these studies suggest that the classroom-level impact of in-service training is contingent not only on the quality of the training itself but on whether accompanying institutional

conditions, time, infrastructure, and leadership support, are in place to allow new practices to be enacted.

Characteristics of Effective Professional Development

A separate strand of literature has focused less on digital pedagogy specifically and more on identifying the general design features that make any teacher professional development effective, findings that are directly applicable to digital pedagogy training. Desimone (2009) proposed a widely cited conceptual framework identifying five core features of effective professional development: a strong content focus, opportunities for active learning, coherence with teachers' existing knowledge and school policies, sufficient duration, and collective participation among colleagues from the same school or department. Desimone's framework further proposes that these design features shape teachers' knowledge, skills, and beliefs, which in turn shape instructional practice, which in turn affects student learning outcomes, establishing a causal chain that links the design of professional development to eventual classroom impact.

Building on this framework, Darling-Hammond et al. (2017), in a review published by the Learning Policy Institute, identified converging evidence that effective professional development is content-focused, incorporates active learning grounded in adult learning theory, and provides sustained duration and follow-up support, rather than one-off workshops. Applied specifically to digital pedagogy, this body of work suggests that in-service training is more likely to produce lasting classroom change when it is embedded in teachers' actual subject-matter teaching, involves hands-on practice with digital tools in authentic instructional tasks, and is sustained through follow-up coaching or professional learning communities, rather than delivered as a single technical workshop disconnected from classroom application.

Theoretical Framework

This review is guided by three complementary theoretical frameworks. First, the Technological Pedagogical Content Knowledge (TPACK) framework, originally proposed by Mishra and Koehler (2006), conceptualises effective technology integration as arising from the dynamic interaction of three knowledge domains: content knowledge, pedagogical knowledge, and technological knowledge. Mishra and Koehler argued that thoughtful pedagogical use of technology requires teachers to develop a complex, situated form of knowledge in which technology, pedagogy, and content are integrated rather than treated as separate competencies. This framework provides a lens for evaluating whether in-service training addresses the integration of technology with pedagogy and content, rather than technology skills in isolation.

Second, Ertmer's (1999) framework of first-order and second-order barriers offers a lens for understanding why training-induced gains in knowledge and confidence may or may not be reflected in actual classroom practice, directing attention to both external, institutional conditions and internal, belief-based conditions that mediate the relationship between training and enacted pedagogy.



Third, Desimone's (2009) core-features framework provides criteria for evaluating the design quality of in-service training programmes themselves, proposing that content focus, active learning, coherence, duration, and collective participation are the design features most strongly associated with subsequent changes in teacher knowledge, beliefs, and instructional practice. Taken together, these three frameworks allow this review to examine not only whether in-service digital pedagogy training affects classroom practices, but why it does so, through which mechanisms, and under what conditions its effects are strongest or weakest.

Research Objectives

This review pursues the following objectives:

To synthesise empirical evidence on the effects of in-service digital pedagogy training on teachers' digital competence, self-efficacy, and beliefs.

To examine the extent to which these training-induced changes are reflected in actual classroom instructional practices.

To identify the institutional, personal, and design-related factors that moderate the relationship between training and classroom practice.

To derive evidence-based recommendations for the design of in-service digital pedagogy training programmes.

Research Questions

What effects does in-service digital pedagogy training have on teachers' digital competence, self-efficacy, and pedagogical beliefs.

To what extent, and through what mechanisms, do these effects translate into changes in classroom instructional practice.

What barriers most commonly prevent the translation of training-induced gains into sustained classroom practice.

Methodology

This paper adopts a systematic literature review and conceptual synthesis design, appropriate for consolidating dispersed empirical findings on a topic where primary studies vary considerably in context, methodology, and scale. The review followed a structured search and selection process rather than a narrative or convenience-based approach, in order to maximise the trustworthiness of the synthesis.

Search Strategy

Relevant literature was identified through structured searches of academic databases and indexing services, including ERIC, ScienceDirect, PubMed Central, and MDPI, alongside targeted searches for foundational theoretical works. Search terms combined variants of "in-service training," "digital pedagogy," "technology integration," "teacher professional development," and "classroom practice." Searches were restricted to peer-reviewed journal articles, systematic reviews, and foundational theoretical papers published in English.

ISSN: 3071-0154 (Online) Inclusion and Exclusion Criteria

Studies were included if they empirically examined the effects of in-service (practising) teacher training related to digital technology or digital pedagogy, reported outcomes related to teacher competence, self-efficacy, beliefs, or classroom practice, and were published in a peer-reviewed outlet. Foundational theoretical papers establishing frameworks central to the field, such as the TPACK and barriers-to-integration frameworks, were also included even where not empirical in design, given their explanatory relevance. Studies focused exclusively on pre-service (initial) teacher education without any in-service component, and studies not available in English, were excluded.

Data Extraction and Synthesis

For each included study, information was extracted on the sample and context, the nature and duration of the training intervention, the outcome measures used, and the reported findings regarding teacher competence, beliefs, and classroom practice. Given the heterogeneity of study designs, ranging from pre-post survey designs to qualitative interview studies and systematic reviews, a narrative thematic synthesis approach was used rather than a statistical meta-analysis. Findings were organised inductively into thematic categories, which subsequently informed the structure of the literature review and results sections of this paper.

Results and Findings

The synthesis of the reviewed literature yields four principal findings regarding the impact of in-service digital pedagogy training on classroom practices.

First, in-service digital pedagogy training consistently improves teachers' self-reported digital competence and self-efficacy, though the magnitude of this effect is moderated by teachers' baseline confidence. The Finnish OpenDigi study found that gains in ICT confidence were concentrated among teachers who began the programme with lower confidence, while already-confident teachers showed little additional change (Pongsakdi et al., 2021). This indicates that a single standardised training format may not be equally effective across a teaching staff with heterogeneous starting competencies, and that differentiated or tiered training may be necessary to benefit all participants.

Second, training that is discipline-specific, practically grounded, and delivered in partnership with subject-matter or technical experts produces stronger gains in professional knowledge and technology-related self-efficacy than generic digital-skills training. The German STEM in-service training study conducted by Reher et al. (2025), delivered through partnerships with university-based student laboratories, reported favourable effects on teachers' professional knowledge, self-efficacy, and technology commitment across eight distinct disciplinary contexts. This supports the broader claim, consistent with Desimone's (2009) content-focus principle, that digital pedagogy training is most impactful when embedded within teachers' actual subject-matter instruction rather than delivered as a decontextualised technical skills course.

Third, the benefits of digital pedagogy training extend beyond instructional competence into teachers' occupational well-being, which may in turn support the sustainability of classroom practice change. Shi et al.'s (2025) study of nearly five hundred teachers in China found that digital pedagogy competence was associated with greater work engagement and reduced

emotional exhaustion, mediated by digital self-efficacy, and that a targeted professional development intervention improved these outcomes. This suggests that training which builds genuine competence and confidence, rather than adding a further burden of poorly supported technology mandates, may protect against the disengagement that can otherwise undermine sustained pedagogical change.

Fourth, and most critically for the impact question, the translation of training-induced competence and confidence into actual classroom practice is not automatic and is shaped by first-order and second-order barriers operating at the institutional and personal levels. Abedi and Ackah-Jnr (2023), studying resource-constrained education settings in Ghana, found that first-order barriers, limited technological resources, inconsistent leadership support, and uneven access to professional development, were perceived as more significant obstacles to classroom-level technology integration than internal, belief-based barriers. Tawfik et al. (2021), examining the emergency shift to online teaching during the pandemic, similarly identified insufficient time for planning and adapting instruction, alongside technical and administrative support gaps, as central obstacles that prevented teachers from applying training-based skills in their actual teaching. These findings collectively indicate that classroom-level impact depends as much on the surrounding institutional environment as on the quality of the training intervention itself.

Discussion

The findings of this review point to a central conclusion: in-service digital pedagogy training is a necessary but not sufficient condition for changing classroom practice. Training programmes that are content-focused, sustained, and grounded in authentic instructional contexts reliably build teachers' digital competence and self-efficacy, consistent with the design principles proposed by Desimone (2009) and with the integrative logic of the TPACK framework (Mishra & Koehler, 2006). These gains are meaningful in themselves; teachers who feel more confident and competent with digital tools are likely to experience less occupational strain and greater engagement with their work, as suggested by evidence linking digital pedagogy competence to reduced emotional exhaustion (Shi et al., 2025).

However, the review also makes clear that competence and confidence gains do not automatically produce changed classroom practice. Ertmer's (1999) distinction between first-order and second-order barriers remains highly relevant a quarter of a century after it was first proposed, and more recent studies confirm that institutional, resource-based barriers frequently outweigh personal, belief-based barriers in shaping whether trained teachers actually change what they do in the



classroom (Abedi & Ackah-Jnr, 2023). This has an important implication for how in-service digital pedagogy training should be evaluated: measuring only teacher knowledge or self-efficacy immediately after training risks overstating the programme's classroom impact if institutional barriers subsequently prevent the application of that training.

A further implication concerns the differentiation of training. Because the effects of training are moderated by teachers' prior confidence levels, uniform, one-size-fits-all training risks under-serving both ends of the confidence spectrum, teachers who are already confident may disengage from training pitched at a basic level, while teachers with low confidence may need more sustained, scaffolded support than a short workshop can provide. This points towards the value of tiered or differentiated in-service training models, an area that remains comparatively under-researched in the reviewed literature.

Finally, the discipline-specific and partnership-based training models examined in this review, particularly the collaboration between schools and university-based laboratories in the German STEM study (Reher et al., 2025), suggest a promising direction for future practice: embedding digital pedagogy training within authentic subject-matter contexts and external expert partnerships appears to strengthen both the perceived relevance and the practical impact of training, compared with generic, decontextualised digital-skills instruction.

Limitations of the Study

This review is subject to several limitations. As a narrative thematic synthesis rather than a statistical meta-analysis, it does not provide a quantified effect size for the impact of in-service digital pedagogy training on classroom practice, and the studies included vary considerably in context, sample size, and methodological rigour. The review draws predominantly on studies from Europe and Asia, which limits the generalisability of its conclusions to education systems with markedly different resource levels or policy contexts. Additionally, most of the reviewed studies rely on self-reported measures of competence, self-efficacy, and beliefs, rather than direct classroom observation, meaning that the extent of actual behavioural change in classroom practice is often inferred rather than directly documented.

Conclusion and Recommendations

In-service digital pedagogy training has become a central mechanism through which education systems seek to prepare teachers for increasingly digitalised classrooms. This review has shown that such training reliably improves teachers' digital competence, self-efficacy, and, in some cases, occupational well-being, particularly when it is content-focused, sustained,

and grounded in authentic subject-matter contexts, consistent with established frameworks including TPACK (Mishra & Koehler, 2006) and Desimone's (2009) core features of effective professional development. However, these gains do not automatically translate into sustained changes in classroom practice. The persistence of first-order institutional barriers, limited resources, insufficient time, and inconsistent leadership support, alongside second-order personal barriers rooted in teachers' beliefs (Ertmer, 1999), means that training must be accompanied by supportive institutional conditions if it is to produce durable pedagogical change.

Based on these findings, several recommendations follow. Education authorities and school leaders should invest in differentiated in-service training models that account for teachers' varying baseline digital confidence, rather than delivering uniform programmes to all staff. Training should be designed around Desimone's core features, with strong content focus, active hands-on learning, coherence with existing curricula, adequate duration, and collective participation among colleagues, rather than delivered as isolated technical workshops. Institutional barriers, including access to infrastructure, allocated planning time, and leadership support, must be addressed in parallel with training delivery, since evidence suggests these first-order barriers often outweigh personal beliefs in shaping classroom-level outcomes. Finally, partnerships between schools and external subject-matter or technical experts, as demonstrated in discipline-specific STEM training models, represent a promising avenue for strengthening the practical relevance and classroom impact of future in-service digital pedagogy training. Future research would benefit from longitudinal, observation-based studies that directly document classroom practice change over time, rather than relying solely on self-reported teacher measures, in order to more precisely establish the causal pathway from training to sustained pedagogical transformation.

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