



ICT-Supported Teacher Professional Development and Self-Directed Learning in Elementary Education: A Literature Review

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Abstract

Information and communication technology (ICT) extends teachers' access to professional learning, yet evidence linking digital development, self-directed learning (SDL), and elementary classroom practice remains uneven. This narrative review synthesizes nine reports concerning ICT-supported teacher professional development and assesses how directly their outcomes apply to elementary education. The sources were drawn from a collection of 85 records identified through Google Scholar, Scopus, Web of Science, ProQuest, and ERIC, covering publications dated 2010–2025. Participants, study designs, learning activities, measures, and reported outcomes were mapped and compared thematically. One longitudinal study documented 12 elementary teachers' online literacy inquiry, while other reports addressed ICT access, perceived professional benefits, and technology-related self-efficacy in mixed-level or non-elementary settings. Across the reports, digital access and positive professional perceptions were more commonly documented than independently observed improvements in elementary teaching or pupil learning. The findings distinguish opportunities to access digital resources, intentional self-directed inquiry, classroom enactment, and pupil outcomes as separate dimensions requiring different evidence. Curriculum-aligned professional development should combine teacher-selected learning goals, critical resource appraisal, professional support, and direct evaluation of classroom implementation.

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1. Introduction

Information and communication technology (ICT) offers teachers access to professional resources, online courses, virtual coaching, and peer networks beyond conventional training events. Such opportunities can overcome geographical and scheduling constraints, but participation in technology alone does not demonstrate professional learning or improvements in classroom practice (Hennessy et al., 2022; Huang et al., 2024; Wang & Hu, 2025). In elementary education, teachers must translate digital resources into age-appropriate decisions about early literacy, foundational numeracy, formative



assessment, and inclusive learning. Reviews of online teacher professional development (TPD) show substantial variation in program design and evaluation, while meta-analytic evidence indicates that teacher-level, classroom-level, and pupil-level outcomes do not change uniformly (Stavermann, 2025; Morina et al., 2025). The central problem is therefore not whether ICT expands access to learning, but whether digitally supported professional development fosters teachers' purposeful learning and produces demonstrable instructional change. Addressing this problem requires a synthesis that differentiates learning processes, measures, and educational contexts rather than treating all positive responses to ICT as evidence of effectiveness.

Teacher professional development refers to learning activities intended to develop teachers' professional knowledge, judgment, and practices; ICT is a possible medium and resource for such activities, not an outcome in itself. Research on TPD increasingly distinguishes between the design of professional learning and the mechanisms by which it may alter professional behavior. Sims et al. (2025) organized those mechanisms around developing insights, motivating change, building techniques, and embedding practice, while Meyer et al. (2023) examined online-program features in relation to teachers' satisfaction and self-reported professional change. Reviews of digital TPD further associate collaboration, feedback, access, and institutional conditions with participants' experiences, although the types of evidence remain heterogeneous (Amemasor et al., 2025; Jin et al., 2024). At the instructional level, a randomized trial of a personalized computer-based mathematics TPD program found gains in pupils' mathematics performance, showing that appropriately evaluated digital interventions can yield stronger evidence than post-course satisfaction alone (Copur-Gencturk et al., 2024). Nevertheless, that experimental finding does not imply an effect of every ICT-supported program, nor does it demonstrate teachers' self-directed learning. The key analytical requirement is to distinguish what technology makes possible, what teachers learn, what they subsequently enact, and what pupils demonstrably gain.

Self-directed learning (SDL) is particularly relevant to ICT-supported professional development because digital environments allow teachers to identify their own professional questions, select resources, and monitor progress. Here, SDL refers to intentional professional inquiry involving needs identification, goal setting, strategic resource selection, critical appraisal, and reflection. It differs from working in isolation, browsing online material, or merely reporting confidence in technology. Beach et al. (2022) documented online learning strategies among 12 elementary teachers during a four-month literacy-focused investigation. Mushayikwa (2013) showed how access conditions can constrain teachers' professional use of ICT, while Coşgun and Savaş (2019) examined technology-supported self-directed development among language teachers from several educational levels. Verster et al. (2024) and Li et al. (2026) further situate teacher-

directed professional learning within curriculum work and emerging digital resources. These studies underscore the need to distinguish purposeful teacher decisions from technology usage frequency and to establish whether professional inquiry subsequently informs teaching.

Three partially connected research streams illustrate what is already known and what remains unsettled. First, studies of online TPD examine pedagogical design, flexible access, and participation, as synthesized by Hennessy et al. (2022), Huang et al. (2024), and Wang and Hu (2025). Second, research on teacher digital competence investigates the knowledge and judgment needed to select, adapt, and evaluate technologies; this literature finds inconsistent definitions and measurement approaches (Heine et al., 2023; Claro et al., 2024; Nguyen & Habók, 2024). Third, evaluations of teacher learning and instructional transfer consider whether perceived growth is supported by performance, artifacts, classroom observation, or pupil results. Li and Copur-Gencturk (2025), for example, directly examined discrepancies between self-perceptions and performance in asynchronous online TPD, while Ventista and Brown (2023) synthesized how professional learning relates to student outcomes across school sectors. The intellectual gap lies between these streams: digital competence is not synonymous with SDL, self-directed inquiry is not synonymous with successful instructional enactment, and evidence concerning one does not automatically validate claims about the others. A defensible synthesis must therefore align populations, constructs, designs, and outcome indicators before interpreting the direction or strength of reported effects.

The elementary-school context makes such distinctions essential. Primary teachers commonly integrate multiple curriculum areas while supporting children with developing literacy, language, numeracy, and self-regulation capacities. Ibda (2023) identified differences among dimensions of elementary teachers' digital competence, suggesting that technical facility should not be equated with evaluative or pedagogical judgment. Reviews of technology-supported equitable instruction and teacher digital literacy likewise demonstrate the importance of instructional fit and critical resource evaluation (Cheah et al., 2023; Fernández-Otoya et al., 2024). Research on elementary literacy innovation and the use of digital learning-platform data also emphasizes curriculum-specific decisions and contextual resources (Rahma et al., 2025; Hase & Kuhl, 2024). Evidence from university lecturers, secondary teachers, teacher educators, and mixed-level populations may illuminate possible mechanisms, but cannot establish elementary classroom outcomes without appropriate population-specific analysis.

Despite growing interest in digital TPD, evidence on teachers' self-direction is often reported alongside findings on access, professional confidence, or perceived instructional benefits, leaving the relationship to classroom enactment

insufficiently clear. This review addresses that conceptual gap through a structured narrative synthesis of nine research reports drawn from a multi-database literature collection. Its objectives are to identify evidence of self-directed professional inquiry, characterize the instructional outcomes measured in ICT-supported development studies, and assess the applicability of those findings to elementary schools. The analysis distinguishes four interconnected but non-equivalent domains: digital opportunity, purposeful teacher learning, instructional enactment, and pupil outcomes. By linking individual reports to the educational level, design, and indicators they actually examined, the study offers a bounded evidence-based account of how ICT-supported professional learning may support integrated elementary education and which outcomes require direct empirical verification.

2. Methods

This study used a structured narrative review with thematic evidence mapping to examine ICT-supported teacher professional development, teachers' self-directed learning (SDL), and reported instructional outcomes. The review addressed three questions: what forms of SDL are documented in ICT-related teacher learning; which professional and classroom outcomes are measured; and how directly the available evidence applies to elementary education. A narrative design was appropriate because the reports differed in their participants, methods, educational levels, and measured outcomes, precluding a defensible pooled effect estimate.

The unit of analysis was the individual research report. The data sources comprised nine publications: Ahmed et al. (2019), Mushayikwa (2013), Beach et al. (2022), Coşgun and Savaş (2019), Suslova et al. (2020), Peter et al. (2024), Osakwe (2013), Gokbel (2020), and Abbasi et al. (2025). These sources included journal articles, conference proceedings, and a doctoral dissertation, representing elementary, mixed-level, secondary, and tertiary educational contexts. Each source was examined for its population characteristics, design, professional learning activity, SDL processes, outcome measures, and applicability to elementary classrooms.

The source collection was assembled using Google Scholar, Scopus, Web of Science, ProQuest, and ERIC, with English-language publications dated 2010–2025. The search topics combined expressions related to ICT, teacher professional development, teachers' self-directed learning, teacher autonomy, and technology-enhanced professional learning. Reference-list examination and related-term searches complemented database retrieval. The documented identification and selection counts were 85 records; 48 records were excluded at title-and-abstract screening; 37 records were assessed in full text; 28 full-text exclusions; and 9 reports were included in the synthesis. Therefore, the review

treats this set as a defined body of source literature rather than as an exhaustive estimate of all relevant publications.

The nine reports were retained for comparative analysis of ICT-supported professional learning and its outcomes. Three primarily addressed self-directed professional learning and enabling conditions; six addressed instructional practices, teaching-related perceptions, or professional confidence. Because the corpus included different participant groups and publication genres, it was examined for evidence of directness instead of assuming that all reports represented comparable elementary-school interventions. Direct evidence referred to outcomes measured among elementary teachers or in elementary classrooms; indirect evidence referred to higher-level, mixed-level, or teacher-education settings. No inference was treated as specific to elementary education unless the study population and measured outcome supported that interpretation.

A structured evidence matrix recorded authorship, publication date, source type, research design, sample, educational level, ICT-supported activities, teacher-learning indicators, instructional measures, and main findings. Evidence was categorized into five domains: digital access and opportunities; self-directed professional inquiry; perceived benefits and technology-related self-efficacy; instructional enactment; and pupil learning outcomes. This organization distinguished reports of participation or professional attitudes from documented teacher activity and independently measured changes in classroom practice. The extraction also recorded whether elementary-specific findings were available or whether conclusions were drawn from mixed or other educational levels.

The analysis proceeded through descriptive mapping of the nine sources, thematic comparison across the five outcome domains, and cross-report synthesis of evidential patterns. Findings were organized into four clusters: observed teacher-directed online inquiry; digital access and perceived opportunities; perceived professional and instructional benefits; and technology self-efficacy or learning contexts outside elementary classrooms. Population, design, measurement, and source-type differences were considered when interpreting the relevance of each cluster. The reporting approach drew on general transparency principles associated with PRISMA 2020 and PRISMA-S (Page et al., 2021; Rethlefsen et al., 2021), without classifying the work as a systematic review or applying quantitative meta-analysis.

3. Results

3.1 Characteristics and Elementary Relevance of the Nine Studies

The evidence corpus comprised nine reports selected from 85 identified records. Their populations and measured outcomes varied substantially: one study directly observed elementary teachers' online learning; one included primary teachers within an undifferentiated multi-level sample; and the remaining

reports examined teachers or learners in other or insufficiently specified educational contexts. Table 1 summarizes the publications and identifies whether each provides direct evidence of elementary teacher learning or only indirect insight into ICT-supported professional development.

Table 1.

Characteristics and elementary relevance of the nine data sources

Source	Population and measured focus	Applicability to elementary education
Ahmed et al. (2019)	222 higher-education respondents; lecturer and student perceptions of ICT and professional development	Indirect: university-level perceptions; no elementary-specific SDL or classroom outcome.
Mushayikwa (2013)	259 advanced-level science/mathematics teachers; professional use of ICT and access barriers	Indirect: barriers reported by advanced-level teachers; approximately 60% noted access difficulties.
Beach et al. (2022)	12 elementary teachers; four-month longitudinal account of online navigation and inquiry	Direct: observed professional inquiry among elementary teachers; classroom and pupil effects not tested.
Coşgun and Savaş (2019)	184 in-service English teachers across primary to tertiary levels reported professional benefits	Mixed-level sample: elementary-specific findings not reported separately; benefits were self-reported.
Suslova et al. (2020).	43 tertiary language students; self-directed language learning; conference proceedings	Indirect: an undergraduate learner sample rather than practicing elementary teachers.
Peter et al. (2024)	338 teachers recruited and 331 analyzed; ICT-related teaching self-efficacy	Indirect: self-efficacy measure rather than observed elementary classroom teaching.
Osakwe (2013)	206 college-of-education lecturers; ICT and teacher-education practices	Indirect: college-of-education lecturers; no elementary classroom outcome.
Gokbel (2020)	Doctoral dissertation on teacher development, self-efficacy, and ICT use	Indirect: dissertation on ICT, teacher development, and professional confidence.
Abbasi et al. (2025)	300 teachers reportedly sampled; publication dated March 2025	Indirect: teacher sample without a separate elementary-specific effect estimate.

Note. Evidence directness is determined by whether the report measures elementary teachers' professional learning or their classroom practices. Source genre and educational level are described to support appropriate interpretation across heterogeneous reports.

The main population pattern is a concentration of indirect evidence. Beach et al. (2022) followed 12 elementary teachers and directly examined their online professional inquiry, whereas Coşgun and Savaş (2019) included primary-school

teachers among 184 in-service language teachers without reporting primary-level estimates separately. Other reports addressed advanced-level science and mathematics teachers, university lecturers, tertiary students, teacher educators, or broadly identified teacher groups. Consequently, the presence of nine reports does not amount to nine studies demonstrating the effects of ICT-supported professional development in elementary classrooms.

3.2 Elementary Teachers' Online Inquiry Provides the Clearest Evidence of SDL

Beach et al. (2022) provide the most direct observation of self-directed professional learning in elementary education. Across four months, the researchers examined how 12 teachers located, selected, evaluated, and used web-based literacy resources. Their findings document actual inquiry and resource-appraisal strategies, rather than relying exclusively on self-reported access or professional attitudes. The study did not test an assigned professional-development intervention against a control condition or establish its effects on observed instruction or pupil achievement.

Mushayikwa (2013) surveyed 259 advanced-level science and mathematics teachers and documented constraints on ICT-supported professional development; approximately three-fifths reported difficulties accessing ICT. Ahmed et al. (2019) investigated 222 higher-education respondents and primarily reported perceptions of ICT-related professional-development opportunities. Together with Beach et al. (2022), these studies describe distinct dimensions of self-directed teacher learning: enacted online inquiry, conditions enabling participation, and perceived professional value. Their designs and populations do not provide comparable causal estimates of SDL improvement.

3.3 Instructional Benefits Are Predominantly Perceived Rather Than Observed

The six reports addressing instruction and professional outcomes focused on heterogeneous indicators. Coşgun and Savaş (2019) analyzed data from 184 English teachers across primary, secondary, and tertiary settings, reporting perceived professional and instructional advantages without conducting separate elementary classroom observations. Osakwe (2013), studying 206 lecturers in colleges of education, examined ICT in teacher-education teaching and resource use. Such results describe perceived or institution-specific benefits; they do not directly measure changes in elementary teachers' classroom practice.

Peter et al. (2024) examined teachers' confidence in using ICT for basic science and technology instruction, reporting 338 teachers recruited and 331 valid questionnaire responses. Technology-related teaching self-efficacy is a relevant professional outcome, but does not establish observed changes in instruction. Gokbel (2020) examined teacher professional development, self-efficacy, and classroom ICT use in a doctoral dissertation; Suslova et al. (2020)

concerned tertiary language students in a conference publication. Abbasi et al. (2025) reported professional-development benefits in a sample of 300 teachers but did not provide an elementary-specific effect estimate. These sources do not support a common estimate of improved elementary instruction because their populations, genres, and outcomes differ.

3.4 Four Evidence Patterns Distinguish Learning from Classroom Outcomes

Cross-report analysis identified four descriptive clusters (Table 2). Only one report directly documented elementary teachers' purposeful online professional inquiry. Other reports examined ICT access, participants' perceptions, teaching-related self-efficacy, or learning contexts that did not isolate practicing elementary teachers. The clusters summarize the types of evidence available, not the size of a shared intervention effect. They also clarify which conclusions require observations or measures beyond those reported by the sources.

Table 2.

Cross-report evidence patterns and outcome boundaries

Evidence pattern (reports)	Data sources	What the findings permit
Observed teacher-directed online inquiry (1)	Beach et al. (2022)	Elementary teachers' online search and resource appraisal were documented; effects on enacted teaching or pupil learning were not tested.
Digital access and perceived opportunity (2)	Mushayikwa (2013); Ahmed et al. (2019)	ICT access constraints and professional-development perceptions were reported in advanced-level and higher-education populations.
Perceived instructional or professional benefits (3)	Coşgun & Savaş (2019); Osakwe (2013); Abbasi et al. (2025)	Perceived benefits and associations were reported, but not isolated for elementary classrooms.
Self-efficacy and non-elementary learning contexts (3)	Peter et al. (2024); Gokbel (2020); Suslova et al. (2020)	ICT-related confidence and non-elementary learning outcomes cannot substitute for observed instructional change; source formats and populations differ.

Note. The clusters are mutually exclusive descriptive groups totaling nine sources (1 + 2 + 3 + 3). Their grouping concerns the type and directness of the evidence, not a comparative quality score or pooled effect estimate.

The strongest observation specific to elementary education concerns how teachers conduct online professional inquiry. ICT access barriers, favorable attitudes, and self-efficacy were also documented, but mainly in different educational populations and with non-equivalent outcome measures. The reviewed sources did not provide consistent, independently observed changes in elementary instruction or directly measured pupil-learning gains. Therefore, their collective contribution presents a differentiated picture of professional learning

opportunities and related outcomes, rather than evidence of a uniform ICT intervention effect.

4. Discussion

4.1 Digital Access Enables Professional Inquiry but Does Not Demonstrate Teacher Agency

Digital access is a necessary opportunity for many forms of online professional learning, but it is not equivalent to teacher agency. Beach et al. (2022) directly observed elementary teachers' resource-selection and appraisal processes, while Mushayikwa (2013) documented substantial ICT access difficulties in an advanced-level teaching population. These findings concern different constructs and are not contradictory: the first describes enacted professional inquiry, and the second a condition that may constrain participation. Reviews of teachers' online learning communities further suggest that professional relevance, facilitation, interaction, and organizational support influence how digital opportunities are used (Jin et al., 2024; Stavermann, 2025). Teacher agency should therefore be evidenced through purposeful decisions and reflective learning behaviors rather than inferred from platform availability.

One reason the evidence may appear contradictory is that technology adoption and teacher agency refer to different mechanisms. Structural access addresses the feasibility of undertaking digital learning, whereas self-directed learning addresses whether the teacher can form and pursue a professional question. Mushayikwa's (2013) finding of access difficulties among roughly three-fifths of survey respondents points to a boundary condition: even highly motivated teachers may have few opportunities to enact a personally chosen learning pathway when connectivity, time, and equipment are constrained. At the same time, the fact that some teachers did not use accessible resources indicates that availability alone cannot account for participation. Rather than explaining these patterns with the general assertion that ICT is useful, the review identifies access, perceived professional relevance, and intentional learning behavior as separate analytic domains.

For elementary teachers, the relation between these domains can be illustrated through curriculum-based professional inquiry. A teacher who recognizes persistent comprehension difficulties may search for an evidence-informed strategy, compare resources, consult a peer, try a classroom adaptation, and subsequently review student responses. Only part of this cycle requires ICT, but digital tools can broaden access to resources, communication, and opportunities for reflection. The educational quality of the process rests on teachers' judgment about the reliability and grade appropriateness of what they find. Beach et al. (2022) provide direct observational evidence relevant to

teachers' online search and reasoning processes, while Sims et al. (2025) offer contextual support for the importance of collaboration, content focus, and feedback. Neither source proves that a particular sequence of activities reliably improves pupil outcomes in the settings reviewed here.

A developmental interpretation is also necessary. Professional learning that is useful for early literacy, basic numeracy, inclusive instruction, or integrative curriculum planning may demand resources different from those used by advanced-level specialist teachers. Ibda (2023) showed that technical digital skills should be distinguished from broader competence domains among elementary teachers, while Rahma et al. (2025) identified infrastructure constraints alongside ICT-supported literacy practice. Both cases reinforce the need to examine how school resources, curricular purpose, and teacher judgment interact, rather than assuming that a generic ICT program transfers unchanged between educational sectors.

Research on digitally supported learning provides plausible explanatory mechanisms for the difference between access and agency. Zimmer and Matthews (2022) highlight the potential of personalized goals and virtual coaching, while Verster et al. (2024) discuss self-directed development in relation to curriculum practices. Li et al. (2026) examine generative AI as a resource for teachers' self-directed professional learning. Taken together, these works indicate that professional choice, feedback, evaluation, and relevant digital resources may operate together. The nine included reports do not isolate or estimate their individual contributions, so the proposed interaction remains an explanation to be tested rather than a demonstrated causal mechanism.

4.2 Professional Confidence Cannot Substitute for Evidence of Classroom Enactment

A second distinction concerns professional perceptions and observable changes in teaching. Reports in the instructional-outcome cluster measured different constructs, including ICT-related self-efficacy, perceived classroom benefits, satisfaction, and teaching experiences in higher education. These outcomes can inform program development without proving that teachers changed classroom practices or improved pupils' learning. Claro et al. (2024) document diversity in the measurement of teachers' digital competence, while Heine et al. (2023) show that digital resource concepts vary across studies. Such variability makes a single claim of improved instruction misleading unless learning processes, instruments, and outcome levels are aligned.

The relationship between digital professional learning and student outcomes is best conceived as a sequence of questions rather than an assumed causal chain. First, teachers need usable access to professional resources; second, they need opportunities to engage in meaningful learning; third, new understanding must be translated into classroom practice; and finally, pupil

outcomes must be measured directly. Evidence at one stage does not establish the next. For example, a self-efficacy questionnaire can identify changes in teachers' confidence using an online assessment system, but it cannot show whether pupils receive better diagnostic feedback. Similarly, expanded access to teaching materials does not demonstrate that those resources were applied effectively or that they led to higher achievement.

Evidence from the wider contextual literature clarifies, but does not erase, that limitation. Meyer et al. (2023) found, in an online professional-development survey of 387 teachers, that cognitive activation and collaboration were associated with teachers' perceived changes in practice. These findings suggest plausible program-design mechanisms. Similarly, Ajani and Govender (2023) emphasized integration of pedagogical and content knowledge with ICT competence in their South African review. Neither source demonstrates an elementary-specific causal pathway in the nine assessed reports. Rather, both indicate why future studies should investigate the educational substance of learning activities instead of defining an intervention solely by the platform that transmits it.

A defensible explanation of professional-development effectiveness requires correspondence between the intended learning mechanism and the outcome selected for measurement. Sims and Fletcher-Wood (2021) question the evidential strength of routinely advocated program features, while Sims et al. (2025) examine mechanisms intended to embed changes in teaching. Their analyses suggest that reported satisfaction or confidence should not be interpreted as the same outcome as classroom practice. Instead, evaluation should identify the learning process under study and test whether the research design supports the proposed relationship between teaching behavior and the learning process.

Research using stronger comparisons illustrates why outcome selection matters. Copur-Gencturk et al. (2024) evaluated personalized computer-based mathematics professional development through a randomized design that included pupil performance. Ventista and Brown (2023) observed that relatively few teacher-learning evaluations establish pupil-level outcomes using rigorous comparative methods, while Mok et al. (2023) synthesized evidence concerning support for novice teachers' self-efficacy. Cheah et al. (2023) documented variation in technology-supported equitable practices across K–12 settings. Recent meta-analyses further differentiate teacher, classroom, and pupil outcomes (Morina et al., 2025; Visscher et al., 2025). These wider studies strengthen the interpretation of the nine sources while remaining separate from the defined review corpus.

4.3 Curriculum Alignment and Support Shape the Elementary Education Implications

The combined findings distinguish four outcome domains: digital opportunity, self-directed professional learning, classroom enactment, and pupil learning. Professional confidence can be assessed as a related teacher-level indicator, but it does not replace evidence from instructional practice. Elementary teachers may access online materials without adapting a lesson, or may report greater confidence without demonstrating increased autonomy in professional inquiry. Effective program design should therefore provide grade-appropriate resources, teacher-selected curriculum questions, opportunities for peer exchange, and feedback tied to classroom application. These are evidence-informed design priorities rather than outcomes established across the nine reviewed studies.

The scholarly contribution lies in specifying what each construct would require as evidence. An ICT opportunity can be documented through access and use logs, teacher agency through teacher-selected goals and reflective learning artifacts, and instructional enactment through lesson plans, classroom observations, or assessment practices. These indicators should be connected analytically only when a study measures the relevant stages and considers alternative explanations. They should not be collapsed into an overall ‘technology effectiveness’ score. In the elementary context, this makes it possible to distinguish a program that simply increases teachers’ digital exposure from one that supports inquiry into specific curriculum challenges. The proposed distinction is a conceptual synthesis of the evidence and its limitations; it remains open to refinement and empirical testing.

Equity further affects the interpretation of digital professional development. Hennessy et al. (2022), synthesizing 170 studies from low- and middle-income countries, found variable outcomes and limited evidence about sustainability, cost-effectiveness, and observable classroom or pupil benefits. Their review also emphasized the continuing importance of facilitators and interpersonal relationships. These observations are pertinent to elementary schools operating with uneven access to devices, connectivity, time, or professional expertise. A digital program may offer nominal access while excluding teachers whose workload or infrastructure prevents meaningful engagement. Conversely, low-cost communication and mentoring arrangements can sometimes support professional exchange where extensive platforms are unavailable. The nine reviewed records are insufficient to estimate these equity effects; the implication is to treat access conditions as study variables rather than as background assumptions. A recent review of teachers’ data literacy likewise shows that dispositions and collaborative data use extend beyond technical skills (Lee et al., 2024).

Curriculum-specific resources could be combined with collaborative lesson planning, explicit criteria for evaluating digital materials, and reflection on classroom adaptations. Documentation of teachers’ learning goals and resource-selection rationales could capture SDL processes; classroom observations and teaching artifacts would be needed to establish instructional change. Table 3 outlines four outcome domains and explains why an indicator in one domain does not by itself demonstrate progress in another.

Reviews of technology-enabled TPD identify the importance of pedagogical feedback, support, reflection, and equitable participation (Huang et al., 2024; Huang et al., 2022). Jin et al. (2024) examine how online-community affordances influence learning, while Amemasor et al. (2025) underscore sustained collaboration and mentoring in digital instructional development. Together, these studies support a program-design approach that addresses subject content and professional relationships rather than defining digital professional development solely by its delivery technology.

The distinction has direct design implications. Online learning should enable teachers to formulate literacy, numeracy, inclusion, or classroom assessment questions, evaluate resources, receive subject-specific feedback, and document adaptations. Ibda (2023) cautions that improvements in technical skills need not generalize to reflective or critical digital competence, and Rahma et al. (2025) illustrate the interaction between technology use and infrastructure in elementary literacy contexts. Broader empirical research has similarly found that digital and online teacher education varies in learning outcomes depending on delivery and pedagogical design (Weng et al., 2023; Stavermann, 2025). Teacher evaluation should therefore separate platform participation, reflective decisions, observable teaching practices, and pupils’ developmental or academic outcomes. In related work, Hase and Kuhl (2024) map how teachers use data from digital learning platforms for instructional decisions, reinforcing the need for direct evidence of classroom enactment.

Table 3.

Proposed outcome domains for future elementary teacher professional-development evaluations

Evidence domain	Indicators appropriate for future studies	Inference not warranted by the domain alone
Digital opportunity	Connectivity, resources available, participation, and use records	Access does not establish autonomous professional learning
Self-directed teacher learning	Teacher-selected learning goals; resource evaluation; reflective records	Learning activity does not prove altered classroom practice
Instructional enactment	Observed teaching, lesson artifacts, assessment tasks, and instructional interactions	Instructional change does not necessarily lead to gains in pupil achievement.

Evidence domain	Indicators appropriate for future studies	Inference not warranted by the domain alone
Pupil outcomes	Appropriate academic, engagement, or developmental indicators	Requires measurement and designs sensitive to rival explanations

Table 3 presents a framework for evaluating ICT-supported development without collapsing distinct outcomes into an overall technology-effectiveness score. Documentation of teacher-directed inquiry would support a claim about professional learning processes; conclusions about classroom improvement or student benefit would require separate measurements and designs appropriate to those claims.

4.4 Evaluation Design Determines the Strength of Instructional Inferences

The scope of the evidence sets important boundaries on interpretation. The nine reports include heterogeneous educational populations, non-journal research formats, and measures spanning access, perception, self-efficacy, and observed inquiry. The source-selection records provide aggregate counts but do not specify database-level retrieval totals, duplicate decisions, or reasons associated with individual full-text exclusions. A common risk-of-bias appraisal and comparable elementary instructional outcome measures are also unavailable. Consequently, the review supports thematic interpretation and evidence mapping, not formal effect-size pooling or causal generalization to elementary classrooms.

Future systematic reviews should register a protocol, specify educational level and eligible research designs, report reproducible search strings for each database, and document full-text exclusion decisions, drawing on PRISMA 2020 and PRISMA-S (Page et al., 2021; Rethlefsen et al., 2021). Independent screening and design-appropriate critical appraisal would enable stronger conclusions. Where samples and measures are sufficiently compatible, separate syntheses could examine effects on SDL behaviors, digital self-efficacy, observed teaching, and pupil learning rather than combine them as interchangeable positive outcomes.

Empirical research in elementary education should evaluate teacher-directed learning and instructional implementation within the same designs. Longitudinal inquiry records, learning artifacts, and resource-appraisal decisions could be paired with lesson observations, instructional materials, formative assessment evidence, and pupil-level indicators. Well-designed comparisons, including experimental or quasi-experimental studies when feasible, would help address alternative explanations. Variation in connectivity, school support, teacher workload, curriculum area, and mentoring should also be measured to explain when and for whom ICT-supported professional development translates into improved classroom practice.

5. Conclusion

The nine studies reveal an important asymmetry between documented digital professional-learning opportunities and directly observed elementary instructional outcomes. The clearest evidence specific to primary education concerns teachers' purposeful online inquiry, whereas other reports primarily address resource access, perceived professional benefits, and technology-related self-efficacy in mixed-level or non-elementary settings. These findings demonstrate that greater digital opportunity and favorable professional perceptions cannot automatically be interpreted as changes in classroom pedagogy or gains in pupil achievement. Therefore, the synthesis identifies teacher-directed inquiry as a promising professional-learning process while preserving the distinction between documented behavior and untested instructional consequences.

For integrated elementary education, the review supports a curriculum-aligned approach to digital professional development that connects teacher-selected questions with critical resource appraisal, collaborative support, and opportunities to enact and reflect on new practices. Its conceptual contribution is a differentiated framework that links digital opportunity, intentional professional learning, instructional enactment, and pupil outcomes without treating them as equivalent measures. Evaluations should document each outcome at the appropriate level and consider school resources and professional support as contextual conditions. Further elementary-focused longitudinal and comparative studies are needed to determine whether, how, and under what conditions ICT-supported professional development improves instruction and children's learning.

Declarations

The author acknowledges the scholarly contributions of the researchers whose studies were synthesized in this review. Grammarly was used for language refinement. Cited sources and bibliographic details were checked against publisher or indexing records. The author remains responsible for the accuracy, originality, interpretation, and final submitted version of the manuscript.

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