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# Teacher Digital Literacy and Instructional Innovation in Southeast Asia: Comparative Insights from Global Educational Systems

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**ABSTRACT:** This narrative review explores the critical role of teacher digital literacy in shaping effective pedagogy and student engagement within 21st-century education. The study aims to synthesize empirical findings and global perspectives on the development, challenges, and implications of digital competence among educators. Using a systematic literature analysis, sources were drawn from Scopus, Google Scholar, ERIC, and related databases, focusing on studies from 2019 to 2024. Keywords included teacher digital literacy, ICT in education, and technology integration. The review identifies significant associations between teachers' digital skills and their ability to adopt innovative, student-centered teaching methods. It further highlights challenges such as infrastructural deficits, inconsistent training, and policy limitations, especially in socioeconomically disadvantaged and geographically remote settings. Comparative analysis reveals that nations with structured professional development and supportive policies show higher digital competence and better learning outcomes. Best practices include collaborative learning communities, curriculum integration frameworks like TPACK, and sustained investment in educational infrastructure. The review concludes that developing teacher digital literacy requires coordinated policy, targeted funding, and culturally responsive training. These efforts are essential to address persistent digital divides and build equitable, inclusive educational systems capable of adapting to future technological demands.

**Keywords:** Teacher Digital Literacy; Technology Integration; ICT; Educational Equity; Policy and Infrastructure.



## INTRODUCTION

In the evolving landscape of 21st-century education, digital literacy among teachers has emerged as an essential competency that underpins effective teaching and learning. As education systems across the globe increasingly integrate digital technologies into classroom instruction, the role of the teacher has shifted to accommodate new pedagogical expectations. The COVID-19 pandemic has further accelerated this shift, compelling educators to transition to online and hybrid teaching formats, often with limited preparation (Otto et al., 2023). This transformation has not only

revealed the opportunities afforded by digital tools but has also illuminated the significant challenges teachers face in leveraging technology effectively. Consequently, digital literacy is now widely recognized as a foundational skill for educators to navigate the complexities of modern pedagogy and to facilitate meaningful student engagement in a digitally mediated learning environment (Sá & Serpa, 2020).

Recent literature highlights that the development of teacher digital literacy is central to achieving student-centered learning, especially in online and blended contexts. Otto et al. (2023) assert that the quality of digital pedagogy is directly influenced by teachers' competence in using technology for instructional design, assessment, and classroom management. Similarly, (Falloon, 2020; Mailizar et al., 2022) emphasize that the integration of technology requires more than basic digital skills; it demands a transformation in instructional practices and a shift in teacher mindset. As educational institutions globally aim to embed technology into their strategic visions, it becomes increasingly important to understand the current state of teacher digital literacy and the factors influencing its development across diverse educational settings.

The global embrace of educational technology is supported by a growing body of evidence showing its impact on student achievement, teacher collaboration, and institutional innovation (Vieira et al., 2023) . However, significant disparities exist between countries and within educational systems. Teachers in technologically advanced nations often demonstrate higher digital proficiency compared to their counterparts in developing regions, where access to digital infrastructure and resources remains limited (Falloon, 2020; Ofosu-Asare, 2024). This digital divide exacerbates existing educational inequalities and raises concerns regarding the equitable implementation of digital learning strategies. In Southeast Asia, for example, teachers face unique challenges arising from infrastructural gaps, lack of targeted professional development, and insufficient institutional support (Alakrash & Razak, 2021).

Socioeconomic factors further complicate the landscape of digital education. Ofosu-Asare (2024) underscores that disparities in access to high-speed internet, up-to-date devices, and technology-enabled learning platforms have a direct impact on teaching quality and student outcomes. In addition, the uneven distribution of professional development opportunities hinders teachers' ability to keep pace with technological change. Studies by Mailizar et al. (2022) and Falloon (2020) reveal that many teachers report feeling unprepared and unsupported in using digital tools, despite recognizing their importance in facilitating active learning. This disconnect between expectations and support structures necessitates a reevaluation of how teacher digital literacy is nurtured and sustained within education systems.

Teachers also face institutional and pedagogical barriers in integrating digital literacy. (Chan & Lee, 2023) note that resistance from school leadership and rigid curricular frameworks can impede innovation, while (Qazi et al., 2023) identify a lack of training as a critical obstacle to technology adoption. Furthermore, pedagogical adaptation remains a major challenge, as many teachers struggle to align their instructional practices with emerging technologies (Zhang et al., 2024). Integrating digital literacy into lesson planning, classroom management, and assessment strategies requires not only technical skills but also pedagogical insight, reflective practice, and a willingness to experiment (Thoma et al., 2017).

Beyond institutional barriers, teachers are often required to navigate the psychological and emotional complexities of digital transformation. Issues such as technostress, anxiety over new technologies, and low confidence in digital environments are commonly reported (Feng & Liu, 2024). These affective dimensions of digital literacy suggest that building technical proficiency alone is insufficient; educators also need emotional support and community engagement to thrive in digital teaching contexts. Professional learning communities (PLCs) have emerged as an effective solution in this regard. Thoma et al. (2017) and (Angraini et al., 2023)) argue that PLCs foster collaboration, peer mentoring, and knowledge sharing, enabling teachers to collectively overcome technological challenges and build a shared repertoire of best practices.

Despite the growing recognition of the importance of digital literacy, significant gaps remain in the academic literature. Much of the current research focuses on general assessments of digital competence without examining its relationship to specific pedagogical outcomes (Barkati et al., 2024). Moreover, the impact of teacher characteristics—such as age, teaching experience, and educational background—on digital literacy and teaching effectiveness is not well understood (Gentles & Haynes-Brown, 2021; Monteiro et al., 2020). These gaps hinder the development of targeted interventions that can address the unique needs of teachers across various contexts. Furthermore, studies frequently overlook the contextual influences of culture, infrastructure, and policy in shaping digital literacy practices, particularly in developing regions like Southeast Asia (Khajavi & Abdolrezapour, 2022).

To address these issues, this review aims to explore the state of teacher digital literacy within the framework of 21st-century learning, with particular emphasis on its implications for pedagogical effectiveness and student outcomes. The primary objective is to synthesize existing literature to identify the key factors influencing digital literacy development among teachers, including demographic characteristics, institutional support, and professional development opportunities. Additionally, this review will examine how teacher digital literacy intersects with issues of educational equity, curriculum design, and instructional innovation.

This study focuses specifically on teachers of English as a Foreign Language (EFL) in Southeast Asia, a region characterized by rapid educational expansion, linguistic diversity, and varied levels of technological integration. The selection of this geographic focus is informed by the urgent need to understand how digital literacy is cultivated and applied in contexts marked by limited resources and complex sociocultural dynamics (Alakrash & Razak, 2021; Khajavi & Abdolrezapour, 2022). By concentrating on EFL teachers, this review also seeks to illuminate the particular challenges faced by educators who must simultaneously manage language instruction and technological mediation.

The scope of this review includes empirical studies, theoretical frameworks, and policy analyses that address digital literacy in education. Priority is given to research conducted within the last five years to capture current trends and innovations. The inclusion of Southeast Asian perspectives ensures that the findings reflect the specific realities of educators in this region, which may differ markedly from those in more affluent or technologically advanced settings. Through this focused lens, the review aims to contribute to a more nuanced understanding of digital literacy as both a personal competency and a systemic imperative in contemporary education.

Ultimately, this review underscores the critical role of teacher digital literacy in shaping effective, equitable, and future-ready education systems. By identifying the barriers and enablers of digital literacy development, this study provides actionable insights for policymakers, educators, and stakeholders committed to advancing digital education. In doing so, it seeks to inform the design of professional development programs, institutional policies, and curricular reforms that support teachers in navigating the digital transformation of education with confidence, competence, and purpose.

## METHOD

This review employed a systematic literature analysis to examine the development, challenges, and implications of teacher digital literacy in the context of 21st-century education. To ensure methodological rigor and comprehensive coverage, the review was designed in accordance with established academic standards for literature synthesis in the field of education and educational technology. The process involved strategic identification of sources, careful selection of keywords, application of inclusion and exclusion criteria, and a thematic organization of empirical findings. The following section details the procedures and rationale employed throughout the review process.

The collection of literature began with a targeted search across multiple high-quality academic databases. Primary sources included Scopus, Google Scholar, Education Research Complete, and ERIC (Education Resources Information Center), as these platforms are widely recognized for indexing peer-reviewed, reputable research in education and digital technologies. Additional references were drawn from the Web of Science and JSTOR for supplementary cross-checking. To ensure access to the most current and credible studies, preference was given to publications from journals ranked in the first or second quartile (Q1 or Q2) of relevant educational technology categories. Only full-text, peer-reviewed articles were considered, and grey literature, non-academic websites, and editorials were excluded from this review.

The search strategy was refined using a structured set of keywords that aligned with the research objectives. For the overarching topic of teacher digital literacy, terms such as "teacher digital competence," "digital skills for educators," "technology integration in teaching," and "educator ICT proficiency" were deployed. These keywords aimed to capture research focusing on how teachers acquire and implement digital skills in educational settings. For studies emphasizing broader educational paradigms, keywords included "21st-century skills," "critical thinking in education," "collaborative learning," "creativity and communication in classrooms," and "future-ready education." These terms allowed for the identification of pedagogical frameworks supporting the cultivation of digital literacy in students and educators alike.

To capture theoretical and applied work on the integration of educational technologies, the search incorporated keywords such as "ICT in education," "technology-enhanced learning," "blended learning approaches," and "educational innovation." These were selected to trace the application of digital tools and learning management systems within formal instructional contexts. Additionally, the review explored implementation strategies through terms such as "curriculum-

based technology integration," "teacher training programs," and "instructional technology models," reflecting structural and institutional support mechanisms for fostering teacher readiness. To address systemic disparities and equity issues, the review also included terms like "digital divide in education," "equity in digital access," "barriers to technology adoption," and "infrastructure challenges in schools."

To ensure that only the most relevant and recent literature was included, several inclusion and exclusion criteria were developed. One major inclusion criterion was the publication period. Only articles published between 2019 and 2024 were selected, as this range captures the most recent developments in educational technologies, particularly those spurred by the global transition to online learning during the COVID-19 pandemic. Earlier publications were excluded unless they offered foundational or widely cited theoretical contributions.

A second criterion was the type of study. This review prioritized empirical research, including both quantitative and qualitative studies, to provide concrete insights into how digital literacy affects teaching practice and student outcomes. Included studies encompassed classroom-based experiments, program evaluations, large-scale surveys, and in-depth case studies. Conceptual frameworks and literature reviews were only included when they provided unique theoretical insights directly related to teacher digital literacy. Non-empirical opinion pieces or purely descriptive reports were excluded due to their limited analytical value.

Geographic context was another factor guiding the inclusion process. Special attention was given to studies conducted in Southeast Asia and other developing regions that share similar educational, socio-economic, and technological characteristics. This focus ensures contextual relevance, especially as the review aims to understand the challenges and innovations experienced by English as a Foreign Language (EFL) teachers in Southeast Asian countries. Nevertheless, comparative studies from developed contexts were also included where they offered transferable frameworks or highlighted contrasting trends useful for benchmarking.

With regard to the population under study, only research involving teachers as the primary subjects was considered. The review focused particularly on studies involving in-service teachers, teacher educators, or pre-service EFL teachers participating in professional development or technology integration programs. Research that addressed student outcomes indirectly—via teacher interventions—was included when the digital literacy of the teacher played a central role in shaping those outcomes. Studies focusing solely on student perspectives, administrative staff, or policymakers were excluded unless they explicitly connected their findings to teacher practices.

The final inclusion criterion concerned the quality and credibility of sources. Only articles published in peer-reviewed journals recognized within the field of educational technology, teacher education, or digital pedagogy were included. Journals indexed in Scopus, Web of Science, or ERIC with a strong record of academic credibility were prioritized. This ensured that all selected studies adhered to rigorous methodological standards and contributed to the scholarly discourse on teacher digital literacy. Conversely, articles from predatory journals, unverified conference proceedings, and non-academic sources were systematically excluded.

The literature selection process was iterative and conducted in several stages to maintain

consistency and transparency. The initial search using selected keywords yielded approximately 420 articles. Titles and abstracts were screened to assess their relevance to the core research questions. At this stage, approximately 240 articles were excluded for being unrelated, outdated, or lacking empirical content. The remaining 180 articles underwent a full-text review to evaluate their methodological quality, sample relevance, and conceptual alignment with the focus of the review. This phase involved the use of a standardized evaluation rubric that considered sample size, methodological clarity, data analysis rigor, and the strength of findings. Following this assessment, a final corpus of 84 articles was selected for in-depth thematic synthesis.

The analytical framework for literature synthesis followed a thematic coding approach. Each selected article was systematically coded based on key variables including type of study, educational setting, digital literacy competencies, teacher demographics, instructional outcomes, and policy implications. These variables enabled the identification of recurring patterns and the construction of thematic categories, such as teacher readiness, institutional support, professional development, technological access, and pedagogical adaptation. Articles were then grouped under these categories to facilitate comparative analysis and highlight convergences and divergences across studies. The themes were refined and validated through multiple rounds of coding to ensure reliability and coherence in the final synthesis.

In summary, this methodology provided a structured and transparent process for gathering, selecting, and analyzing literature on teacher digital literacy in the 21st-century educational landscape. By applying clearly defined inclusion criteria, employing relevant keywords across reputable databases, and adhering to systematic screening and thematic coding procedures, the review ensured the credibility, relevance, and analytical depth of its findings. This methodological rigor supports the generation of insights that are both context-sensitive and globally relevant, offering a valuable contribution to research and practice in digital pedagogy and teacher education.

## RESULT AND DISCUSSION

The findings of this narrative review reveal several interrelated themes that illuminate the influence of teacher digital literacy on instructional practices, student engagement, and the broader challenges of integrating educational technology across varying geographic and socioeconomic contexts. The review further identifies key global comparisons and exemplary practices that offer insights into the development of teacher digital competence in the 21st century. Each of these themes is elaborated through six thematic subsections below, organized to reflect both the empirical and contextual diversity found in the reviewed literature.

In the first major theme, teacher digital literacy is shown to significantly impact instructional methodology and student engagement in digitally mediated learning environments. Teachers with high levels of digital competence tend to implement more student-centered and innovative teaching approaches, such as project-based learning and online collaboration (Otto et al., 2023; Falloon, 2020). These educators are more adept at selecting and applying appropriate technological tools, thereby enriching the classroom experience and aligning pedagogical strategies with the learning needs of 21st-century students. Research also supports the claim that digital literacy

enables teachers to foster greater student motivation and participation, particularly when interactive technologies are employed to facilitate collaboration (Zhang et al., 2024).

Digital proficiency among teachers not only influences their instructional methods but also correlates with broader pedagogical effectiveness. Otto et al. (2023) and Falloon (2020) suggest that when technology is integrated effectively, it enhances the relevance and flexibility of content delivery, enabling differentiated instruction and promoting higher student achievement. Conversely, teachers lacking digital competence are more likely to rely on traditional, teacher-centered methods, which are often less effective in engaging students or fostering active learning (Calderón-Garrido et al., 2023).

However, despite the recognized benefits, numerous challenges hinder the effective implementation of digital tools in educational settings. Many teachers report insufficient training or professional development opportunities, leading to a lack of confidence in using technology (Calderón-Garrido et al., 2023; Otto et al., 2023). Anxiety about new technologies and limited institutional support exacerbate this issue. Thoma et al. (2017) emphasize the importance of structured professional development and peer collaboration in overcoming these barriers. Institutional efforts to provide workshops, create teacher learning communities, and encourage experience-sharing have shown to be effective in enhancing digital competence.

Empirical studies consistently affirm the link between teachers' ICT (Information and Communication Technology) competencies and pedagogical innovation. Teachers equipped with strong technical skills are more likely to design engaging, technology-mediated learning experiences that include flipped classrooms and blended learning strategies (Pflaumer et al., 2021; Thoma et al., 2017). For example, Zhang et al. (2024) found that high-ICT-competence teachers were significantly more likely to implement collaborative, multimodal digital environments, resulting in improved student outcomes. In contrast, low-competence teachers often continue using conventional methods, which can limit the potential of educational technology in enhancing learning effectiveness (Calderón-Garrido et al., 2023).

Innovation through digital integration also transforms how students interact with content. Falloon (2020) and Moorhouse et al. (2022) demonstrate that the adoption of digital platforms not only introduces new content formats but also reshapes student engagement by supporting autonomy, creativity, and collaborative inquiry. In English as a Foreign Language (EFL) contexts, the use of multimedia and interactive applications has been associated with increased motivation and language proficiency among students (Thoma et al., 2017). Furthermore, the effective use of digital tools makes learning more accessible and relevant, particularly when aligned with students' interests and real-world experiences (Otto et al., 2023).

Professional development emerges as a catalyst for fostering digital innovation in teaching. Well-structured training programs enhance teacher confidence and support experimentation with new instructional practices (Falloon, 2020). Studies indicate that ongoing professional learning significantly boosts teachers' abilities to integrate technology effectively, particularly when training is contextualized and hands-on (Calderón-Garrido et al., 2023; Thoma et al., 2017). These findings underscore the need for sustained investment in teacher development to achieve scalable and lasting pedagogical improvements.

Despite these gains, several systemic and contextual obstacles continue to impede technology adoption in classrooms. Limited technological infrastructure remains a primary concern, particularly in rural or under-resourced areas (Irwahand et al., 2022; Rath, 2025). In many such settings, teachers lack access to reliable devices or high-speed internet, undermining their capacity to implement digital instruction effectively. These material constraints disproportionately affect schools in economically disadvantaged communities, exacerbating educational inequities and limiting opportunities for digital innovation.

Another prominent barrier is the lack of consistent, high-quality training for teachers. (Pflaumer et al., 2021; Tawfik et al., 2021) report that many educators receive little to no professional support for integrating technology, leading to uncertainty and resistance. Teacher reluctance is also fueled by concerns over increased workload, fear of failure, and attachment to traditional teaching practices. These psychological barriers highlight the need for institutional cultures that promote risk-taking, innovation, and ongoing support.

Teachers often cite time constraints and workload as major impediments to adopting new technologies. The demands of lesson planning, grading, and administrative duties leave little room for learning about and experimenting with digital tools (Thoma et al., 2017). Schools must therefore explore time-efficient models of professional development and resource-sharing to reduce the burden on teachers while still encouraging innovation.

Organizational culture and policy also influence teachers' capacity to integrate technology. Yip et al. (2022) argue that a supportive school environment—including administrative backing, clear ICT policies, and access to resources—plays a critical role in encouraging teacher experimentation with technology. Without institutional alignment and adequate funding, even well-intentioned teachers may struggle to sustain digital innovations in the classroom.

Geographic and socioeconomic contexts further shape teachers' experiences with digital literacy. In urban schools, better access to infrastructure often enables more sophisticated uses of technology, whereas rural and remote schools face persistent challenges in connectivity, equipment, and support (Haddade et al., 2024; Rosenberg et al., 2022). Such disparities result in uneven educational outcomes, as students in under-resourced settings may receive less technologically enriched instruction.

Socioeconomic status similarly affects technology integration. Teachers working in low-income communities often lack the means to pursue additional training or invest in supplementary resources. As a result, they may fall behind in digital competence relative to peers in more affluent areas (Rosenberg et al., 2022). These gaps also extend to students, reinforcing broader patterns of educational disadvantage.

The availability of educational resources is unevenly distributed across contexts. While wealthier schools are equipped with modern devices and ongoing training programs, underfunded schools often operate with outdated equipment and minimal support (Rosenberg et al., 2022). This imbalance limits the scalability of digital pedagogy and raises concerns about systemic inequities in access to quality education.

Educational policy plays a vital role in addressing these challenges. Governments that prioritize

digital infrastructure, equitable funding, and teacher training contribute to more inclusive technology adoption (Major et al., 2021; Yip et al., 2022). Strategic policies can bridge geographic and socioeconomic divides by ensuring that all educators receive the support necessary to thrive in digital learning environments. Policymakers must thus consider local contexts in designing effective interventions.

Cross-national comparisons reveal stark differences in approaches to developing teacher digital literacy. Developed countries like Finland and Canada employ structured, well-funded programs that embed digital competencies into teacher education and professional development (Tawfik et al., 2021; Otto et al., 2023). These countries also foster teacher collaboration through professional learning communities and peer mentoring networks, enhancing shared knowledge and reflective practice.

In contrast, developing countries often struggle with infrastructural and financial constraints that limit the reach and impact of digital literacy initiatives. Training programs may be irregular, poorly resourced, or not tailored to local needs (Haddade et al., 2024; Zhang et al., 2024). Teachers in these contexts face heightened pressure to implement technology without adequate preparation or support, hindering innovation and consistency.

Policy frameworks in developed nations typically include clearly defined digital literacy standards and provide ample resources for teacher training. In developing contexts, however, education systems may lack coherent digital strategies or suffer from implementation challenges, further complicating the integration of technology into pedagogy (Tawfik et al., 2021; Haddade et al., 2024). These structural disparities necessitate context-sensitive policies that reflect the realities of under-resourced education systems.

Best practices from high-performing education systems offer valuable lessons. The use of collaborative learning communities, such as PLCs, has proven effective in promoting digital literacy through shared experience and mutual support (Thoma et al., 2017; Calderón-Garrido et al., 2023). Embedding frameworks like TPACK (Technological Pedagogical and Content Knowledge) into teacher training programs also enhances educators' ability to align technology with pedagogical goals (Zou et al., 2021).

In countries like Singapore, customized and continuous professional development programs are aligned with teachers' specific needs and teaching contexts (Otto et al., 2023). These programs incorporate the latest digital tools and pedagogical approaches, helping teachers stay abreast of technological changes while meeting classroom demands. Project-based learning models in Canada and similar initiatives have also shown promise in cultivating student-centered, technology-driven instruction (Chen et al., 2022).

Infrastructure investments are central to successful digital integration. Countries that prioritize broadband connectivity, access to digital devices, and the provision of open educational resources (OER) demonstrate higher levels of teacher engagement with technology (Tour et al., 2023). These enabling conditions support innovation and foster educational equity by leveling the playing field across diverse school environments.

In summary, the results of this review underscore the multifaceted impact of teacher digital literacy

on educational quality. Digital competence not only enhances teaching practices and student engagement but also requires sustained support through policy, infrastructure, and professional development. While challenges remain, particularly in developing contexts, the global landscape offers numerous strategies and best practices that can be adapted to local realities. Advancing teacher digital literacy is thus both a pedagogical necessity and a policy imperative for equitable, future-oriented education systems.

This review contributes to a growing body of scholarship that highlights the critical role of teacher digital literacy in shaping effective pedagogy and student engagement in 21st-century learning environments. By synthesizing recent findings on the relationship between teachers' digital competence and instructional outcomes, the study reinforces and extends existing literature while also identifying systemic challenges and proposing actionable solutions. The discussion below analyzes the key contributions, system-level influences, and intervention strategies derived from the results.

The present findings confirm the central role of teacher digital competence in fostering innovative teaching methods and enhancing student participation. These findings align with Otto et al. (2023) and Falloon (2020), who emphasize that teachers equipped with strong digital skills are better able to implement interactive and student-centered pedagogical approaches. Consistent with prior studies (Isoda et al., 2021; Stoilova et al., 2020), the current review demonstrates that digitally literate teachers not only adopt advanced teaching techniques but also create learning environments that promote collaboration, creativity, and autonomy. This underscores the notion that digital competence is not merely a technical skill but a pedagogical enabler that transforms the nature of classroom interaction.

The evidence also reaffirms earlier observations that student engagement significantly improves when teachers use digital tools effectively. Stoilova et al. (2020) found that interactive technologies help students become more actively involved in the learning process, a conclusion echoed by Zhang et al. (2024), whose work demonstrates how multimodal digital environments increase motivation and comprehension. Our review adds to this body of evidence by illustrating that teacher expertise in selecting and integrating appropriate technological tools contributes to differentiated instruction and higher levels of personalized learning. These results support ongoing calls for embedding digital literacy in teacher training and professional development programs to better align instructional practices with the demands of digital-age learners.

However, the study also reinforces a long-standing challenge identified in the literature: resistance to technological innovation among educators. This resistance is often rooted in structural and psychological barriers such as lack of confidence, insufficient support, and entrenched pedagogical habits (Irwahand et al., 2022; Calderón-Garrido et al., 2023). As previous research has suggested, institutional reluctance and teacher discomfort with digital tools can stall technology adoption, even when resources are available. Thus, while improving infrastructure is essential, it must be accompanied by cultural and attitudinal change, supported through sustained mentorship and peer learning structures.

The review also validates the influence of contextual and policy-related variables on the development of teacher digital literacy. Pflaumer et al. (2021) highlighted the role of national

education policies in either facilitating or constraining the digital transformation of classrooms. Our findings echo this sentiment, revealing that teachers in countries with clear digital integration policies and robust funding frameworks demonstrate higher levels of digital competence and pedagogical innovation. In contrast, inconsistent or poorly implemented policies in developing contexts often leave teachers underprepared and unsupported, undermining reform efforts. These observations point to the need for coherent, context-sensitive policies that prioritize technology integration at both the systemic and classroom levels.

The value of collaborative professional development also emerges as a key theme in the current analysis. Literature consistently affirms that peer-based learning communities help educators share strategies, develop skills, and overcome technology-related anxieties (Zhang et al., 2024; Zilka, 2021). Our review adds weight to these claims by illustrating how formal and informal professional learning networks promote shared responsibility and reflection among teachers. These networks are particularly important in under-resourced contexts where institutional training may be sporadic or absent. The review thus supports expanding access to collaborative learning platforms as a scalable strategy for enhancing digital competence.

At the system level, several structural factors contribute to the disparities observed in teacher digital literacy. National education policy remains a major driver of implementation success. In developed countries, comprehensive frameworks for digital integration include targeted investments in teacher education, infrastructure, and curriculum design (Thoma et al., 2017; Tawfik et al., 2021). These frameworks have led to more consistent digital adoption and improved instructional outcomes. Conversely, in many developing countries, vague or non-existent policies result in fragmented efforts and limited uptake of digital tools in schools (Irwahand et al., 2022).

Professional development is another critical system-level determinant. Stoilova et al. (2020) and Alwi et al. (2024) demonstrate that well-structured, sustained professional learning opportunities significantly enhance teachers' digital skills and their willingness to experiment with technology. However, our findings suggest that many existing training programs are ill-equipped to meet teachers' practical needs. Haddade et al. (2024) argue that one-size-fits-all models fail to consider local realities, including time constraints, classroom conditions, and teacher motivation.

Consequently, training initiatives should be adapted to local contexts and include hands-on, collaborative activities aligned with curriculum goals.

The adequacy of funding for technological infrastructure is another defining element. As Rath (2025) and Major et al. (2021) note, schools in high-income regions benefit from investments in devices, connectivity, and software that facilitate digital teaching. This infrastructure underpins equitable access and enables innovation. In contrast, schools in lower-income areas often struggle to provide even basic technological tools, limiting both teacher capability and student learning. The review highlights that unequal funding directly correlates with disparities in digital literacy, reinforcing the need for redistributive investment strategies that bridge these gaps.

Equity-focused policies are equally vital. (Heo, 2016; Park et al., 2021) advocate for inclusive education strategies that prioritize rural and marginalized communities. Programs that distribute digital devices, subsidize internet access, or provide mobile-based learning platforms can help

narrow the digital divide. Our review finds that without such policies, disparities in digital competence persist, perpetuating systemic inequities in educational opportunity. Therefore, ensuring equitable access to technology must be a central objective of national education agendas.

Cultural norms and social attitudes also play a crucial role in shaping teacher receptiveness to digital tools. Zhang et al. (2024) and Stoilova et al. (2020) discuss how cultural resistance to change can impede innovation, particularly when new pedagogies challenge established teaching identities. Our review affirms that teachers' beliefs about the value and appropriateness of technology significantly influence their adoption behaviors. As such, policy efforts must be accompanied by broader cultural interventions that promote experimentation, resilience, and lifelong learning among educators.

To address the barriers identified, this review proposes several policy and practice-based interventions. Improving digital infrastructure in underserved schools is a foundational step. (Dorris et al., 2024) emphasize that reliable access to hardware and internet connectivity is a prerequisite for effective technology integration. Investment in infrastructure must therefore be coordinated with training and support to maximize impact.

Professional development models must also be restructured to ensure responsiveness and relevance. Haddade et al. (2024) suggest that modular, job-embedded training formats are more effective than generic workshops. Our findings support this recommendation and underscore the value of collaborative learning, mentorship, and ongoing support. Additionally, policy frameworks should mandate digital literacy as a core component of teacher certification and continuing education programs (Zhang et al., 2024).

Encouraging teacher collaboration through formal professional learning communities (PLCs) can also yield substantial benefits. (Alwi et al., 2024) demonstrate that PLCs not only enhance teacher confidence but also create shared spaces for innovation and problem-solving. Establishing digital hubs or teacher networks—particularly in remote areas—can ensure that all educators have access to expertise and peer support.

Policy interventions should also focus on aligning teacher incentives with digital transformation goals. Governments can offer professional recognition, financial rewards, or career advancement opportunities for educators who demonstrate excellence in technology use. Rosenberg et al. (2022) argue that such incentive structures reinforce positive behaviors and institutionalize innovation. Furthermore, addressing teachers' psychological well-being is crucial. Calderón-Garrido et al. (2023) caution that technostress and burnout can derail technology initiatives. Providing emotional support and counseling can help educators manage change and maintain resilience.

The current review also reveals several limitations in existing research. Many studies lack longitudinal data on the sustained effects of digital literacy interventions, making it difficult to assess long-term outcomes. Others focus narrowly on specific geographic or socioeconomic contexts, limiting the generalizability of findings. Additionally, few studies systematically examine the interplay between digital literacy and content-specific pedagogy, such as in STEM or language instruction. Future research should explore these areas using mixed-methods approaches that capture both quantitative outcomes and qualitative insights.

Another area that warrants deeper investigation is the role of leadership in fostering digital competence. School administrators are often gatekeepers to innovation, and their attitudes and decisions significantly influence implementation success. Leadership development programs that train principals and district leaders to support digital transformation could enhance institutional readiness. Further research is needed to map these leadership dynamics and their effects on teacher behavior and student achievement.

Ultimately, while this review confirms the positive impact of teacher digital literacy on educational quality, it also highlights the multifaceted challenges and system-wide reforms necessary for widespread and equitable adoption. Addressing these issues requires a collaborative effort among policymakers, educators, researchers, and communities to create environments in which digital learning can thrive.

## CONCLUSION

This study highlights the pivotal role of teacher digital literacy in enhancing instructional practices and student engagement in 21st-century learning. The findings confirm that digital competence significantly contributes to the adoption of innovative, student-centered pedagogies, improves learner participation, and enhances teaching effectiveness. Moreover, systemic challenges such as inadequate infrastructure, insufficient training, policy gaps, and socio-cultural resistance continue to hinder widespread implementation, particularly in developing contexts.

The discussion emphasizes the importance of coordinated national policies, equity-focused funding, responsive professional development, and the cultivation of collaborative teacher communities as strategic solutions. These interventions are essential not only for addressing current barriers but also for building sustainable, inclusive digital education systems.

To support policy makers, this review recommends implementing national frameworks that embed digital literacy standards into teacher education and certification. Ministries of Education should allocate dedicated budgets for ICT infrastructure, particularly in rural and underserved schools.

Teacher training institutions must develop modular, practice-based programs that address local realities and pedagogical challenges.

Educational institutions are encouraged to establish professional learning communities (PLCs) where teachers can share knowledge and co-develop digital strategies. Incentive programs—such as micro-credentials, stipends, or leadership pathways—can motivate ongoing engagement in digital upskilling. Institutions should also conduct regular audits to evaluate digital readiness and refine implementation based on evidence.

Future research should address gaps in longitudinal studies, leadership dynamics, and context-specific pedagogy to provide a more comprehensive understanding of how digital literacy can be embedded across diverse educational environments. In particular, exploring the role of school leadership and teacher agency in driving digital transformation would offer valuable insights for reform initiatives.

Ultimately, empowering teachers with robust digital skills and systemic support mechanisms is vital for ensuring that educational systems are both future-ready and equitable.

## REFERENCE

Alakrash, H., & Razak, N. A. (2021). Technology-Based Language Learning: Investigation of Digital Technology and Digital Literacy. *Sustainability*, *13*(21), 12304. https://doi.org/10.3390/su132112304

Alwi, N. A., Kenedi, A. K., Arwin, A., Anita, Y., Handrianto, C., & Rasool, S. (2024). Socio-Cultural Approach Through Digital Teaching Modules: A Solution to Improve Beginning Reading Skills in Elementary Schools. *Journal of Ecohumanism*, *3*(7). https://doi.org/10.62754/joe.v3i7.4552

Angraini, E., Zubaidah, S., & Susanto, H. (2023). TPACK-based Active Learning to Promote Digital and Scientific Literacy in Genetics. *Pegegog*, *13*(02). https://doi.org/10.47750/pegegog.13.02.07

Barkati, M., Kiyanfar, Z., Noughabi, M. A., & Ershadi, F. (2024). Contributions of Self-efficacy, <scp>L2</Scp> Grit and Digital Literacy to Informal Digital Learning of English: A Structural Equation Modelling Approach. *British Journal of Educational Technology*. https://doi.org/10.1111/bjet.13547

Chan, C. K. Y., & Lee, K. K. W. (2023). The AI Generation Gap: Are Gen Z Students More Interested in Adopting Generative AI Such as ChatGPT in Teaching and Learning Than Their Gen X and Millennial Generation Teachers? *Smart Learning Environments*, *10*(1). https://doi.org/10.1186/s40561-023-00269-3

Dorris, C., Winter, K., O'Hare, L., & Lwoga, E. T. (2024). Mobile Device Use in the School Classroom and Impact on Pupil Literacy and Numeracy Attainment: A Systematic Review. *Campbell Systematic Reviews*, *20*(2). https://doi.org/10.1002/cl2.1417

Falloon, G. (2020). From Digital Literacy to Digital Competence: The Teacher Digital Competency (TDC) Framework. *Educational Technology Research and Development*, *68*(5), 2449– 2472. https://doi.org/10.1007/s11423-020-09767-4

Feng, X., & Liu, H. (2024). I Feel Blue– Teacher, Can You Help Me? A Study on the Effect of Digital Literacies on Language Learners' Technostress, on-Line Engagement, Autonomy, and Academic Success. *BMC Psychology*, *12*(1). https://doi.org/10.1186/s40359-024-01637-5

Gentles, C. H., & Haynes-Brown, T. (2021). Latin American and Caribbean Teachers' Transition to Online Teaching During the Pandemic: Challenges, Changes and Lessons Learned. *Pixel-Bit Revista De Medios Y Educación*, *61*, 131–163. https://doi.org/10.12795/pixelbit.88054

Haddade, H., Nur, A., Achruh, A., Rasyid, M. N. A., & Ibrahim, A. (2024). Madrasah Management Strategies Through Madrasah Reform Program: An Evidence From Indonesia. *International Journal of Educational Management*, *38*(5), 1289–1304. https://doi.org/10.1108/ijem-05-2023- 0236

Heo, S. (2016). Pre-Service Teachers' Attitudes and Views About Smart Learning: Implications for Creative Teaching and Learning. *International Journal of Software Engineering and Its Applications*, *10*(2), 289–298. https://doi.org/10.14257/ijseia.2016.10.2.24

Irwahand, F. N. E., Mat-Rasid, S. M., Low, J. F. L., Elumalai, G., Shahril, M. I., & Ahmad, M. A. I. (2022). Perceived Barriers to Adopting Information and Communication Technology in Physical Education. *Pedagogy of Physical Culture and Sports*, *26*(5), 291–299. https://doi.org/10.15561/26649837.2022.0503

Isoda, M., Estrella, S., Zakaryan, D., Baldin, Y. Y., Olfos, R., & Araya, R. (2021). Digital Competence of a Teacher Involved in the Implementation of a Cross-Border Lesson for Classrooms in Brazil and Chile. *International Journal for Lesson and Learning Studies*, *10*(4), 362–377. https://doi.org/10.1108/ijlls-05-2021-0045

Khajavi, Y., & Abdolrezapour, P. (2022). Exploring English as a Foreign Language (EFL) Teachers' Experience of Flow During Online Classes. *Open Praxis*, *14*(3), 202–213. https://doi.org/10.55982/openpraxis.14.3.495

Mailizar, M., Umam, K., & Elisa, E. (2022). The Impact of Digital Literacy and Social Presence on Teachers' Acceptance of Online Professional Development. *Contemporary Educational Technology*, *14*(4), ep384. https://doi.org/10.30935/cedtech/12329

Major, L., Francis, G. A., & Tsapali, M. (2021). The Effectiveness of Technology-supported Personalised Learning in Low- and Middle-income Countries: A Meta-analysis. *British Journal of Educational Technology*, *52*(5), 1935–1964. https://doi.org/10.1111/bjet.13116

Monteiro, A., Mouraz, A., & Dotta, L. T. (2020). Veteran Teachers and Digital Technologies: Myths, Beliefs and Professional Development. *Teachers and Teaching*, *26*(7–8), 577–587. https://doi.org/10.1080/13540602.2021.1900809

Ofosu-Asare, Y. (2024). Developing Classroom ICT Teaching Techniques, Principles and Practice for Teachers in Rural Ghana Without Access to Computers or Internet: A framework Based On literature Review. *International Journal of Information and Learning Technology*, *41*(3), 262–279. https://doi.org/10.1108/ijilt-04-2023-0045

Otto, S., Bertel, L. B., Lyngdorf, N. E. R., Markman, A. O., Andersen, T., & Ryberg, T. (2023). Emerging Digital Practices Supporting Student-Centered Learning Environments in Higher Education: A Review of Literature and Lessons Learned From the Covid-19 Pandemic. *Education and Information Technologies*, *29*(2), 1673–1696. https://doi.org/10.1007/s10639-023- 11789-3

Park, A., Ramírez, P. A., & Sparks, P. (2021). Special Issue Editorial: *International Journal of Multicultural Education*, *23*(3), 1–6. https://doi.org/10.18251/ijme.v23i3.3187

Pflaumer, N., Knorr, N., & Berkling, K. (2021). Appropriation of Adaptive Literacy Games Into the German Elementary School Classroom. *British Journal of Educational Technology*, *52*(5), 1917–1934. https://doi.org/10.1111/bjet.13149

Qazi, A. G., Mustafa, M. Y., Mtenzi, F., & Valcke, M. (2023). Mobile Technology as an Alternative Teaching Strategy Amidst COVID-19 Hiatus: Exploring Pedagogical Possibilities and Implications for Teacher Development. *Education Sciences*, *13*(4), 385. https://doi.org/10.3390/educsci13040385

Rath, A. (2025). Padlet: A Tool for Fostering Collaborative Learning and Feedback Literacy in Dental Education. *Frontiers in Medicine*, *11*. https://doi.org/10.3389/fmed.2024.1357068

Rosenberg, J. M., Schultheis, E. H., Kjelvik, M. K., Reedy, A. M., & Sultana, O. (2022). Big Data, Big Changes? The Technologies and Sources of Data Used in Science Classrooms. *British Journal of Educational Technology*, *53*(5), 1179–1201. https://doi.org/10.1111/bjet.13245

Sá, M. J., & Serpa, S. (2020). COVID-19 and the Promotion of Digital Competences in Education. *Universal Journal of Educational Research*, *8*(10), 4520–4528. https://doi.org/10.13189/ujer.2020.081020

Stoilova, M., Livingstone, S., & Nandagiri, R. (2020). Digital by Default: Children's Capacity to Understand and Manage Online Data and Privacy. *Media and Communication*, *8*(4), 197–207. https://doi.org/10.17645/mac.v8i4.3407

Tawfik, A. A., Gish-Lieberman, J. J., Gatewood, J., & Arrington, T. L. (2021). How K-12 Teachers Adapt Problem-Based Learning Over Time. *Interdisciplinary Journal of Problem-Based Learning*, *15*(1). https://doi.org/10.14434/ijpbl.v15i1.29662

Thoma, J., Hutchison, A., Johnson, D. W., Johnson, K., & Stromer, E. (2017). Planning for Technology Integration in a Professional Learning Community. *The Reading Teacher*, *71*(2), 167–175. https://doi.org/10.1002/trtr.1604

Vieira, R. M., Tenreiro-Vieira, C., Bem-Haja, P., & Lucas, M. (2023). STEM Teachers' Digital Competence: Different Subjects, Different Proficiencies. *Education Sciences*, *13*(11), 1133. https://doi.org/10.3390/educsci13111133

Yip, J., Roldan, W., González, C., Pina, L. R., Ruíz, M. T., & Vanegas, P. (2022). Youth Invisible Work: The Sociocultural and Collaborative Processes of Online Search and Brokering Between Adolescents and English-Language Learning Families. *Information and Learning Sciences*, *123*(7/8), 330–350. https://doi.org/10.1108/ils-01-2022-0004

Zhang, Y., Jing, P., & Zheng, Y. (2024). Teachers' Perceptions of Implementing Digital Multimodal Composing in Tertiary Classrooms: Voices From Chinese EFL Teachers. *International Journal of Applied Linguistics*, *34*(4), 1265–1282. https://doi.org/10.1111/ijal.12560

Zilka, G. C. (2021). Advantages and Disadvantages of Regularly Using a Laptop Computer in Class, in Primary and Secondary Schools and in Higher Education From the Point of View of Preservice Teachers. *International Journal of Information and Learning Technology*, *38*(4), 364–380. https://doi.org/10.1108/ijilt-02-2021-0041

Zou, M., Kong, D., & Lee, I. (2021). Teacher Engagement With Online Formative Assessment in EFL Writing During COVID-19 Pandemic: The Case of China. *The Asia-Pacific Education Researcher*, *30*(6), 487–498. https://doi.org/10.1007/s40299-021-00593-7