Curricula: Journal of Curriculum Development *- e-ISSN 2830-7917 & p-ISSN 2964-7339*
Volume 4 No 1 (2025) 909-924

Curricula:
Journal of Curriculum Development
https://ejournal.upi.edu/index.php/CURRICULA/

Strengthening pedagogical competence of elementary teachers in the digital era

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ABSTRACT

Digital transformation requires elementary school teachers to have pedagogical competencies that are not only strong in theory but also adaptable to technological developments. This article aims to examine strategies for strengthening the pedagogical competencies of elementary school teachers in the digital age. This study employed a systematic literature review method, comprising four stages of analysis: identification, screening, feasibility testing, and inclusion. Data were collected from various academic sources, including scientific journals, articles, and relevant books, with a focus on literature published between 2020 and 2025. The results of the study indicate that pedagogical competencies in the digital age involve integrating digital literacy, technology-based learning innovations, and collaborative skills. Challenges include infrastructure limitations, low digital literacy, and resistance to change. Effective strategies to address these challenges include continuous training, strengthening professional communities, and institutional policy support. Best practices identified include digital project-based learning, the use of Learning Management Systems (LMS), and the development of online teacher communities. This study emphasizes the importance of collaboration among teachers, schools, and policymakers in developing an innovative and sustainable basic education ecosystem in the digital age.

ARTICLE INFO

Article History:
Received: 29 Mar 2025
Revised: 19 Jun 2025
Accepted: 21 Jun 2025
Available online: 27 Jun 2025
Publish: 27 Jun 2025

Keywords:
digital transformation;
elementary school teachers;
pedagogical competence

Open access
Curricula: Journal of Curriculum Development is a peer-reviewed open-access journal.

ABSTRAK

Transformasi digital menuntut guru sekolah dasar memiliki kompetensi pedagogik yang tidak hanya kuat secara teoritis, tetapi juga adaptif terhadap perkembangan teknologi. Artikel ini bertujuan untuk mengkaji strategi penguatan kompetensi pedagogik guru sekolah dasar di era digital. Kajian ini dilakukan melalui metode systematic literature review dengan empat tahapan analisis, yaitu identifikasi, penyaringan, uji kelayakan, dan inklusi. Data dikumpulkan dari berbagai sumber akademik seperti jurnal ilmiah, artikel, dan buku yang relevan, dengan fokus pada literatur terbitan tahun 2020-2025. Hasil kajian menunjukkan bahwa kompetensi pedagogik di era digital melibatkan integrasi literasi digital, inovasi pembelajaran berbasis teknologi, serta keterampilan kolaboratif. Tantangan yang dihadapi meliputi keterbatasan infrastruktur, rendahnya literasi digital, dan resistensi terhadap perubahan. Strategi efektif untuk mengatasinya meliputi pelatihan berkelanjutan, penguatan komunitas profesional, serta dukungan kebijakan institusional. Praktik baik yang ditemukan mencakup pembelajaran berbasis proyek digital, pemanfaatan Learning Management System (LMS), dan pengembangan komunitas guru daring. Studi ini merekomendasikan pentingnya kolaborasi antara guru, sekolah, dan pemangku kebijakan dalam membangun ekosistem pendidikan dasar yang inovatif dan berkelanjutan di era digital.

Kata kunci: *guru sekolah dasar; kompetensi pedagogik; transformasi digital*

How to cite (APA 7)
Ahyar, A., & Herlambang, Y. T. (2025). Strengthening pedagogical competence of elementary teachers in the digital era. *Curricula: Journal of Curriculum Development, 2*(1), 909-924.

Peer review
This article has been peer-reviewed through the journal's standard double-blind peer review, where both the reviewers and authors are anonymised during review.

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https://doi.org/10.17509/curricula.v4i1.84679

INTRODUCTION

The development of digital technology has brought fundamental changes to various aspects of life, including education. The shift in the educational paradigm brought about by technological advances has prompted educational institutions to adjust their learning approaches (Haleem et al., 2022). Digital transformation in the education sector depends not only on infrastructure but also on the readiness of human resources, especially teachers, to adapt quickly and effectively. Elementary school teachers play a strategic role in this process because they are at the forefront of shaping students' knowledge and skills.

In this era of rapid digital transformation, elementary school teachers must go beyond subject mastery to understand student characteristics and manage effective learning. The demands of 21st-century education require ongoing enhancement of pedagogical competencies to address evolving challenges and diverse student needs (Somantri, 2021). Literature also shows that strong pedagogical skills, combined with professional literacy, significantly impact teacher performance, including in madrasahs with similar roles (Haz & Sugianto, 2022). Strengthening these competencies is thus essential for improving the quality of basic education, which focuses on holistic student development.

The challenges faced by elementary school teachers in the digital age are more complex than they were in the past. Teachers not only need to master the subject matter but also understand the characteristics of the digital generation they are teaching. Technology offers opportunities to improve the quality of learning, but if not managed wisely, it can have negative impacts on student development (Winantika, 2022). Teachers are expected to be able to operate digital platforms, such as Learning Management Systems (LMS), as well as utilize interactive media and multimedia-based instructional materials. Multimedia tools, including digital presentations, video and audio resources, e-learning platforms, webinars, and video conferencing, have become widely used in educational institutions to enhance instructional quality (Rumiantseva et al., 2023). Unfortunately, limited access to training, technical support, and administrative burdens continue to be significant obstacles to improving teacher capacity. If not handled properly, digital transformation could become an additional burden. Therefore, a strategy is urgently needed to strengthen contextual and needs-based pedagogical competencies.

Pedagogical competence is a core component of teacher professionalism as stipulated in national regulations on teacher professional standards. This competence encompasses the ability to design, implement, and evaluate learning professionally, taking into account the characteristics of students. In the digital age, teachers are expected to design learning experiences that are informative, collaborative, and adaptable to technological advancements. Teachers with strong pedagogical competencies are more innovative and responsive to students' learning needs (Fakhrutdinova et al., 2020). Digital-based pedagogical competencies are crucial in the process of transforming learning from conventional methods to modern approaches. Empirical studies also demonstrate that pedagogical competence significantly contributes to teacher performance and student learning outcomes. Pedagogical and professional competence greatly influence teacher performance improvement (Murkatik et al., 2020).

https://doi.org/10.17509/curricula.v4i1.84679

Globally, various countries have developed innovative approaches to enhance teachers' pedagogical competencies by integrating professional skills with contextual and value-based pedagogical practices to foster inclusive and adaptive education. In the Indonesian context, for instance, the integration of digital technology in Islamic education has strengthened teachers' pedagogical capabilities, increased student engagement, and enriched learning strategies that are contextual (Hidayat et al., 2023). Furthermore, using technology as a tool for training and reflecting on teaching practices has proven effective in various studies. Digital simulations, instructional videos, and online training through learning management systems (LMS) can support teachers' pedagogical development (Supkhonovna, 2021). In this regard, technology functions as a learning ecosystem that facilitates collaboration and continuous reflection. However, several studies have found that many teachers are still unable to optimally adapt to these changes, particularly in utilizing technology for learning. Low technology proficiency remains a barrier to the use of interactive learning media (Sari et al., 2023). Moreover, many teachers, both pre-service and in-service, still lack confidence in integrating technology into their teaching (Polly et al., 2023; Raihan & Nurzalkinah, 2024; Yurna, 2023). This indicates a gap between the current demands for digital competencies and the pedagogical skills that teachers currently possess.

Despite the growing body of literature that emphasizes the importance of pedagogical competence in the digital era, studies that comprehensively synthesize strategies for strengthening elementary teachers' pedagogical competencies by integrating national and international perspectives remain limited. This study aims to fill this gap by presenting a contextual and adaptive framework for enhancing pedagogical competence in Indonesia, drawing on best practices and evidence from global and national sources. Therefore, the purpose of this study is to identify strategic approaches derived from relevant scientific literature that can systematically and sustainably strengthen teachers' pedagogical competencies, particularly in the context of digital transformation.

LITERATURE REVIEW

The Concept of Teacher Pedagogical Competence

Pedagogical competence refers to a teacher's ability to manage and facilitate learning effectively, taking into account students' characteristics, learning principles, and educational goals. This competence encompasses the skills to design, implement, and evaluate learning activities that are engaging, contextually relevant, and oriented toward student development. Teachers' mastery of subject content and their pedagogical ability have been shown to significantly influence students' academic achievement, particularly in secondary schools (Qadeer et al., 2024). Likewise, the ability to teach adaptively has a statistically significant positive effect on student performance (Brühwiler & Vogt, 2020). In the context of elementary education, where the developmental stage of students is critical, strengthening pedagogical competence becomes an essential requirement for ensuring quality and meaningful learning experiences.

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Challenges of Pedagogical Competencies in the Digital Transformation Era

The shift toward digital education presents significant challenges for teachers, particularly in adapting their pedagogical practices to meet the needs of modern learners. Many still require contextually sensitive training to apply digital skills effectively (Huong et al., 2025). In elementary schools, teachers often feel overwhelmed by the demands of content delivery, classroom management, and digital tools, further strained by limited tech acceptance, skill gaps, heavy workloads, and student behavioral issues (Althubyani, 2024). Meanwhile, the diverse learning styles of digital-native students demand a deeper understanding of generational shifts; without it, technology use risks disengagement or cognitive overload.

Integration of Technology in Strengthening Pedagogical Competencies

Technology offers opportunities not only to support teaching but also to enhance pedagogical competence through innovation and reflection. Training and development interventions that involve the creation or design of open educational initiatives should emphasize the promotion of diverse open educational practices, such as the use, creation, distribution, and mobilization of digital resources (Patiño et al., 2023). Furthermore, innovative approaches that leverage technology are essential for achieving improved educational outcomes. In this regard, the integration of Artificial Intelligence (AI) into Learning Management Systems (LMS) represents a transformative approach to enhancing the effectiveness and personalization of digital learning environments (Ikhsan et al., 2025). However, many schools still face practical constraints such as limited internet access, inadequate technical infrastructure, and a lack of ongoing mentoring. As such, it is necessary to design pedagogical capacity-building programs that are responsive to contextual challenges, combining technology with continuous professional development tailored to the needs of each school.

Global Approach to Improving Pedagogical Competence

Several countries have implemented innovative approaches to strengthening teachers' pedagogical competencies, which can serve as references in the Indonesian context. In Finland, improving teacher competence is pursued through reflective, collaborative, and humanistic practices. The significance of combining professional expertise with context-sensitive pedagogical values to cultivate inclusive and adaptive educational practices is extensively underlined (Ranta et al., 2023). Meanwhile, in Uzbekistan, the development of pedagogical proficiency among prospective teachers is considered a vital component of contemporary education (Xolbayeva, 2025). In Poland, digitalization has moved teaching from traditional to flexible online models (Nermend et al., 2022). This reflects a global call for education to align with social, economic, and technological change (Bajac & Fišer, 2024). These examples illustrate that strengthening pedagogical capabilities must be aligned with an in-depth understanding of learners' characteristics, school environments, and supportive educational systems. Therefore, it is essential to design educational policies that facilitate the structured, ongoing, and research-informed advancement of pedagogical competencies.

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METHODS

This study employed a systematic literature review method designed to compile, evaluate, and synthesize various published research findings, thereby offering a comprehensive understanding of how to strengthen the pedagogical competencies of elementary school teachers in response to digital advancements (Andriani, 2021). Data were collected from credible sources, including scientific journals, academic articles, and reference books that discuss pedagogy, digital innovation in education, and teacher professional development. The review process followed four structured stages: identification, screening, eligibility assessment, and inclusion (Sastypratiwi & Nyoto, 2020). The findings were then concluded through a thorough and detailed analytical approach, resulting in final insights that are relevant and aligned with the research objectives (Ardana et al., 2025).

The identification stage was conducted by searching for scientific articles through online databases using keywords tailored to the study's focus, with publications dating from 2020 to 2025. In the screening stage, researchers evaluated the titles and abstracts of articles to eliminate publications that were thematically or contextually irrelevant. Subsequently, the feasibility testing stage was conducted by thoroughly reading the content of the articles to ensure their scientific quality, prioritizing articles that had undergone peer review. In the final stage, namely inclusion, articles that met the standards of quality and academic relevance were selected for further analysis. All these stages were conducted following scientific ethical principles, including avoiding plagiarism, maintaining objectivity in assessment, and ensuring transparency in reporting the study results. To assist in managing reference sources, the researchers used the Mendeley reference management software.

RESULTS AND DISCUSSION

Understanding of Elementary School Teachers' Pedagogical Competencies in the Digital Age

Teachers' pedagogical competencies in the digital age have experienced a significant expansion. Beyond mastering learning theories and teaching strategies, these competencies now encompass digital skills that are transformative in educational settings. A key element is teachers' digital competency, which involves understanding, operating, and applying technology meaningfully to enhance student engagement. In this context, digital literacy emerges as a core dimension. It includes not only finding and evaluating information but also understanding ethical and cybersecurity aspects. Teachers with strong digital literacy guide students to critically assess and apply information in relevant ways, while fostering responsible digital behavior (Jalaluddin, 2024). These skills also enable teachers to create interactive learning through access to global resources and collaboration tools (Umarovich & Ollaberganovna, 2025).

Elementary teachers today must go beyond traditional pedagogical knowledge and develop technopedagogical skills that require an understanding of how cognitive flexibility influences the effective integration of technology in teaching. This shift redefines pedagogical competence, combining digital tools with established strategies to enrich learning experiences. Information literacy also plays a vital role in supporting learning outcomes.

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Teachers must be able to search, manage, and process digital content efficiently, skills that enhance both instructional quality and student engagement (Ibda et al., 2022). Continuous development of these competencies is necessary in response to technological advances (Hussain & Jamil, 2024).

Pedagogical competence in the digital era is not just about using tools but also about applying ICT to uphold professional teaching practices (Jay, 2023). Technology serves as a means, not an end, in optimizing learning. Therefore, teachers must combine technological proficiency, global awareness, student counseling roles, and readiness for future challenges. Digital literacy, as part of this, includes both technical and critical information skills (Sele & Dewi, 2025). Ultimately, elementary teachers' pedagogical competence must be seen as a multidimensional integration of pedagogy, technology, digital and information literacy, and instructional innovation. This holistic skill set is key to creating adaptive, contextual, and future-ready learning (Orakova et al., 2024).

Strategies Applied to Improve Pedagogical Competencies

Amidst the rapid development of the digital era, improving the pedagogical competencies of elementary school teachers is a necessity. Teachers are required not only to master teaching materials and learning methodologies but also to utilize technology appropriately in the teaching process (Utomo, 2023). Therefore, a systematic and sustainable strategic approach is needed to achieve optimal digital skill enhancement.

One of the main strategies is to conduct structured and continuous training. Systematic training plays a significant role in enhancing traditional teaching methods, practical teaching strategies, technical knowledge, and both pedagogical and technical components (Khan et al., 2022). This training must be tailored to teachers' needs and the latest technological developments so that it is not only informative but also practical. Training can take the form of courses, workshops, or seminars that emphasize the improvement of digital skills, the introduction of the latest learning applications, and the practice of integrating technology into learning activities. Additionally, interactive training activities offer teachers an opportunity to share experiences and strategies that have proven successful in the classroom.

Another strategy is to strengthen teachers' digital literacy. In this case, teachers are equipped with the ability to search for information, process data, and integrate digital content into lesson plans. Strong digital literacy will enable teachers to design more contextual and interactive learning media and activities. This strategy is fundamental, considering that pedagogical competence encompasses the ability to select appropriate and relevant learning approaches, methods, and strategies in a digital context (Orakova et al., 2024).

Collaboration among teachers is also an integral aspect of strengthening pedagogical competence. Encouraging cooperation in the context of utilizing educational technology can enhance collective competence. Teachers can collaborate in developing digital teaching materials, designing technology-based learning projects, and providing feedback to one another within professional learning communities. These communities serve as essential platforms for sharing best practices and exchanging educational resources. Teachers need to act as facilitators by managing technology as a learning medium (Rintayati & Syawaludin,

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2022). In line with this, teachers with strong pedagogical competencies will be more effective in the teaching and learning process (Masrur, 2021). Therefore, building a supportive learning community is an important step in strengthening collective competencies.

Another supporting factor is the availability of adequate digital learning infrastructure and ecosystems. Schools need to ensure they have sufficient technological devices, fast internet access, and responsive technical services, so that teachers can innovate in the teaching process. A school environment that supports the use of technology, both in terms of physical facilities and digital culture, will accelerate teachers' adaptation to using technology pedagogically (Nugraha et al., 2020). Additionally, teachers should be given opportunities to explore various digital learning media and platforms. Tools such as Google Classroom, digital comics, and interactive multimedia, including immersive technologies like augmented reality, can significantly enhance student engagement, conceptual understanding, and learning motivation through interactive and visually rich experiences. Moreover, these technologies support a constructivist learning approach that encourages students to build their understanding actively (Kusuma, 2025). This exploration enables teachers to continuously innovate and tailor their teaching strategies to suit the needs of today's digital-native learners.

Challenges Faced by Elementary School Teachers in Implementing Digital Pedagogy

The rapid development of digital technology has significantly impacted various aspects of life, including education, subtly influencing people's mindsets, lifestyles, and attitudes. While technology offers vast and fast access to information that should enhance the learning process, elementary school teachers still face challenges in implementing digital-based pedagogical competencies (Hadiapurwa et al., 2021). A key issue is the limited access to technology and the lack of relevant training, which creates a gap between the demands of digital learning and teachers' readiness to meet these demands. This gap is further widened by persistent disparities in digital access, technological skills, and educational outcomes, particularly affecting marginalized communities in both urban and rural areas (Tang et al., 2025).

In addition to infrastructure issues, challenges also arise from the uneven digital literacy of teachers. Although some teachers possess basic knowledge of using technology, not all of them can effectively integrate it into the learning process. Teachers also need to be able to adapt to the characteristics of 21st-century learners who are active, critical, and accustomed to the digital environment. In this regard, teachers are required to possess critical thinking skills, problem-solving abilities, effective communication, and strong collaboration skills, which encompass both technical skills and social-emotional competencies in managing increasingly complex digital classrooms (Chien, 2020; Van Laar et al., 2020).

Teachers are also required to continually update their knowledge and skills to remain relevant in today's times. Continuous improvement in ICT literacy is crucial so that the learning designed can meet the needs of today's students (Ibda et al., 2023). Teachers' inability to adapt to technological changes can reduce the quality of educational services. On the other hand, attitudes or mindsets also pose a challenge, as many teachers still feel anxious or

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reluctant to use technology. In fact, with the right approach, technology can be a tool that strengthens the learning process, rather than an additional burden.

Another challenge comes from teachers' low skills in using digital devices and media. Many teachers have not mastered the various technological tools that can support learning. Additionally, the process of integrating technology often presents challenges in time management, including planning, preparation, and implementation of classroom learning. Teachers must also consider the aspects of cybersecurity, data protection, and the need for adaptive cybercrime regulations, all of which intersect with the integration of technology in education (Li & Zhang, 2025).

More broadly, key aspects of educational technology integration include digital skills, resistance to change, uneven infrastructure, and institutional support. While some teachers are already utilizing technology, significant barriers remain, including limited ICT access, low digital literacy, inadequate training, weak school policy support, and psychological constraints that hinder effective integration (Robandi et al., 2025). In addition, many teachers feel burdened by the need to adapt to rapid technological developments without sufficient digital readiness (Sudorová et al., 2025). Infrastructure gaps and insufficient pedagogical training, particularly in early childhood and basic education, also pose significant challenges, as current programs often prioritize technical over instructional applications, such as digital game-based learning or online formative assessment (Novida, 2025). Therefore, strong institutional support and comprehensive training are crucial in enabling teachers to address these challenges effectively.

To address these challenges, strategic and sustainable measures are necessary. The importance of continuous professional training and development, which emphasizes improving teachers' digital literacy and technological skills, is essential (Al Hudaya et al., 2024). In addition, the availability of supporting infrastructure must be expanded to remote areas. The use of technology also needs to be balanced with conventional methods that are still relevant, as well as supportive education policies from the school to the government level.

Today’s teachers are expected to develop knowledge and skills and act as learning facilitators. Technological advances present vast opportunities to enhance teacher competence, necessitating robust institutional support. Building a digital learning environment that fosters student interaction, collaboration, and critical thinking strengthens the need for professional collaboration among teachers. Strengthening professionalism also requires the development of adaptive skills, including critical thinking, problem-solving, creativity, and digital literacy. Teachers’ openness to new ideas, digital awareness, and self-confidence remain key assets in driving digital transformation (Listiyoningsih et al., 2022). Moreover, the quality of professional development is determined by how well educational institutions manage learning components efficiently to support student achievement.

Best Practices as a Reference Model for Competency Strengthening

Several best practices have been identified as effective models for enhancing the pedagogical competencies of elementary school teachers in the digital age. One such approach is a school-based training program that is scheduled and tailored to the actual needs of teachers.

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This strategy has proven effective because it can accommodate local contexts and the specific challenges faced by teachers. In addition, activities such as seminars, peer mentoring, and workshops are commonly employed to help teachers integrate learner-centered pedagogical approaches, including problem-solving, inquiry-based learning, project-based learning, and design-based learning, into their daily teaching practices (Cyprian et al., 2025).

Digital project-based learning models are also a best practice that elementary school teachers have widely adopted. By utilizing technology platforms, teachers can design collaborative learning experiences that not only hone students' academic skills but also familiarize them with digital culture. Teachers must be able to integrate technological skills with pedagogical strategies to make learning more meaningful (Orakova et al., 2024). Another practice worth noting is the use of cloud-based learning management systems, which enable teachers to design, track, and evaluate learning more efficiently. The digital era is characterized by the transition to cloud-based and paperless systems, so teachers who successfully adopt these systems demonstrate high competence in managing modern learning (Nurabadi et al., 2022).

The development of digital-based teacher communities, such as online learning groups or professional discussion forums, is a practice that supports the strengthening of competencies. Teachers with high digital competencies can effectively utilize tools and technology in the teaching process, as recent research has noted. This community serves as a platform for exchanging experiences, sharing solutions, and fostering a lifelong learning spirit among teachers (Kiryakova & Kozhuharova, 2024).

Finally, the planned and contextual integration of ICT in the learning process is key. Teachers who can adapt ICT-based learning strategies to meet the needs of individual students will produce more effective learning outcomes. Digital literacy and teaching experience have a significant influence on teachers' pedagogical competencies, as demonstrated by research. Therefore, these best practices need to be documented and replicated as part of a national strategy to strengthen teachers' pedagogical competencies (Anggraini et al., 2024).

Discussion

Based on the results of the literature review analyzed in four main areas, a conceptual synthesis shows a close relationship between improvement strategies, implementation challenges, and best practices in strengthening the pedagogical competencies of elementary school teachers in the digital transformation era. Strategies such as continuous training, digital literacy development, professional communities, and exploratory spaces directly address real challenges, including low digital literacy, limited infrastructure, resistance to change, and gaps in techno-pedagogical skills. Recent findings indicate that teachers' digital literacy significantly predicts their pedagogical and technological competencies (Orakova et al., 2024), while institutional barriers, such as inadequate training and resistance to innovation, persist. Therefore, targeted training initiatives and supportive regulations are crucial for enhancing digital pedagogical readiness.

Best practices such as cloud-based LMS, digital project-based learning, and online teacher communities are concrete manifestations of these strategies. These practices mutually reinforce one another to address systemic issues. Needs-based internal training helps bridge

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digital literacy gaps, while online communities support mindset shifts by offering spaces for collaborative learning and peer reflection (Sümer, 2021). Cloud-based LMS improves planning, collaboration, and instruction in project-based contexts (El Koshiry et al., 2024), while digital tools integrated into PBL enhance students' grammar, comprehension, and vocabulary in speaking classes (Hoesny et al., 2024). These interconnected practices support a sustainable learning cycle and form the basis of a holistic conceptual model.

The synthesis has implications for both educational theory and practice. Theoretically, it reinforces the relevance of technopedagogical and connectivism approaches in designing digital learning. Connectivism emphasizes digital networks in knowledge construction, which is crucial for teacher communities, while the TPK approach highlights the integration of pedagogy, content, and technology in a contextual context (Ismail et al., 2023; Mukhlis et al., 2024). Practically, there is a need for a paradigm shift toward collaborative, andragogical, and reflective learning models. Practices such as peer discussions, reflective journaling, and revisiting teaching approaches deepen reflection and foster critical thinking (Kamali & Javahery, 2024). This supports a transformational model of professional development that focuses on solving classroom problems through the use of contextual digital tools.

As a contribution, this study proposes an integrative conceptual model combining: (1) structural and individual challenges, (2) digital competency development strategies, and (3) replicable best practices. This aligns with findings that highlight the importance of sustained, structured digital training for primary teachers, which incorporates technical, pedagogical, and reflective components (Alférez-Pastor et al., 2023). The model presents a dynamic cycle linking challenges, strategies, and outcomes centered on digital pedagogical competence. Systematic reviews emphasize the importance of a comprehensive framework for developing this competence (Basilotta-Gómez-Pablos et al., 2022). Effective methods include blended learning, peer collaboration, and context-specific training, all of which are reinforced by institutional support (El-Hamamsy et al., 2024; Novriyanto et al., 2025).

This open conceptual model evolves in response to policy shifts and regional readiness. Its novelty lies in merging conceptual and empirical insights into a transformative framework. Strengthening teacher capacity amid digital transformation requires not only individual effort but also systemic support from all educational actors. First, teachers must build awareness and motivation to adapt, participate in digital training, improve information literacy, and engage in online communities. They should develop technopedagogical competencies to integrate technology into planning, instruction, and assessment, while encouraging inclusive digital classrooms (Fernández-Otoya et al., 2024; Novita et al., 2022). Second, principals must lead the development of digital ecosystems through need-based training, mentoring, infrastructure provision, and fostering an innovation-friendly school culture. Such a culture encourages teachers to act as facilitators, curriculum implementers, collaborators, and digital content creators in primary schools, especially in the post-pandemic context (Wijayanti et al., 2024). Third, policymakers should provide regulatory and financial support that aligns with curriculum reform and promotes equitable access, especially in 3T areas. Prioritizing strategic digital integration strengthens education systems (Mukul & Büyüközkan, 2023). Fourth, teacher training institutions should design flexible, blended programs addressing local needs, with a focus on ed-tech, digital content, and assessments. Post-training digital mentoring enhances teacher growth and fosters a collective mindset. All education stakeholders must work collaboratively within a transformative ecosystem. Blended training

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boosts technology readiness, while online communities support pedagogical enrichment and innovation decentralization (Ibrohim et al., 2024). Thus, teacher competence transformation must be managed as a collaborative, cross-sector process.

CONCLUSION

This literature review confirms that strengthening elementary school teachers' pedagogical competencies in the digital era is an urgent necessity. These competencies now extend beyond conventional strategies to include the integration of ICT, digital literacy, instructional innovation, and collaborative, contextual learning. The findings suggest that such multidimensional skills are essential for fostering adaptive and competitive learning in the digital age. Teachers face complex challenges in implementing digital pedagogy, including infrastructure gaps, low digital literacy, resistance to change, and weak policy support. These can be addressed through integrated strategies such as practice-based training, online learning communities, digital literacy development, and innovation spaces. Effective practices like cloud-based LMS and digital project-based learning show that digital transformation is achievable through gradual, structured efforts. As a scientific contribution, this article proposes a conceptual model for enhancing teachers' digital pedagogical competencies through the interplay of challenges, strategies, and best practices. It underscores the synergy among teachers, school leaders, policymakers, and training institutions in building a collaborative and sustainable education ecosystem. The model aims to inform policy, training design, and institutional reform, thereby supporting teacher professionalism in the digital era. For future research, it is recommended that this conceptual model be empirically tested in various educational contexts and regions, its practical impacts on classroom practices and student outcomes explored, and measurement instruments developed to assess the effectiveness of digital pedagogical competence development programs.

AUTHOR'S NOTE

The authors declare that there is no conflict of interest in the publication of this article and guarantee that this manuscript is free from plagiarism.

REFERENCES

Al Hudaya, R., Zakiah, A., & Fahira, N. A. (2024). Tantangan profesional guru di era digital. *Cemara Education and Science, 2*(3), 1-7.

Alférez-Pastor, M., Collado-Soler, R., Lérida-Ayala, V., Manzano-León, A., Aguilar-Parra, J. M., & Trigueros, R. (2023). Training digital competencies in future primary school teachers: A systematic review. *Education Sciences, 13*(5), 1-18.

Althubyani, A. R. (2024). Digital competence of teachers and the factors affecting their competence level: A nationwide mixed-methods study. *Sustainability*, *16*(7), 1-24.

Andriani, W. (2021). Penggunaan metode sistematik literatur review dalam penelitian ilmu sosiologi. *Jurnal PTK dan Pendidikan*, *7*(2), 124-133.

https://doi.org/10.17509/curricula.v4i1.84679

Anggraini, T., Ahmad, M., & Hanafi, I. (2024). Digital literacy and teaching experience as predictors of pedagogical competence in the digital era. *Tarbawi: Jurnal Keilmuan Manajemen Pendidikan, 10*(2), 295-306.

Ardana, A. F., Akbar, R. S., & Martadireja, O. (2025). Systematic literature review dengan metode prisma: Pemanfaatan chatbot. *JATI (Jurnal Mahasiswa Teknik Informatika)*, *9*(3), 4507-4514.

Bajac, M., & Fišer, M. (2024). Digital transformation and new educational paradigm. *Social Informatics Journal, 3*(1), 1-8.

Basilotta-Gómez-Pablos, V., Matarranz, M., Casado-Aranda, L. A., & Otto, A. (2022). Teachers' digital competencies in higher education: A systematic literature review. *International Journal of Educational Technology in Higher Education*, *19*(1), 1-16.

Brühwiler, C., & Vogt, F. (2020). Adaptive teaching competency: Effects on quality of instruction and learning outcomes. *Journal for educational research online*, *12*(1), 119-142.

Chien, C. W. (2020). Analysis of elementary school English teachers' professional dialogue as their professional development. *Australian Journal of Teacher Education, 45*(5), 1-17.

Cyprian, D., Chikuvadze, P., Young, M., Daimond, D., & Claretah, M. (2025). Competence-based education pedagogy and its infusion into primary school learning activities: Experiences from teachers in a selected cluster in Eswatini. *Journal of Educational Research and Practice*, *3*(1), 1-15.

El Koshiry, A., Eliwa, E., Abd El-Hafeez, T., & Tony, M. A. A. (2024). Effectiveness of a cloud learning management system in developing the digital transformation skills of blind graduate students. *Societies*, *14*(12), 1-23.

El-Hamamsy, L., Monnier, E. C., Avry, S., Chessel-Lazzarotto, F., Liégeois, G., Bruno, B., ... & Mondada, F. (2024). An adapted cascade model to scale primary school digital education curricular reforms and teacher professional development programs. *Education and Information Technologies*, *29*(9), 10391-10436.

Fakhrutdinova, A. V., Ziganshina, M. R., Mendelson, V. A., & Chumarova, L. G. (2020). Pedagogical competence of the high school teacher. *International Journal of Higher Education, 9*(8), 84-89.

Fernández-Otoya, F., Cabero-Almenara, J., Pérez-Postigo, G., Bravo, J., Alcázar-Holguin, M. A., & Vilca-Rodríguez, M. (2024). Digital and information literacy in basic-education teachers: A systematic literature review. *Education Sciences*, *14*(2), 1-20.

Hadiapurwa, A., Susilana, R., & Rusman, R. (2021). Kesiapan calon guru sekolah dasar pada pelaksanaan kurikulum dalam kondisi khusus. *Pedagogia, 19*(2), 126-138.

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3*(1), 275-285.

https://doi.org/10.17509/curricula.v4i1.84679

Haz, A. M., & Sugianto, E. S. (2022). Analisis pentingnya kompetensi pedagogik dan literasi digital guru dalam upaya meningkatkan kinerja guru. *JSG: Jurnal Sang Guru, 1*(3), 207-214.

Hidayat, W. N., Nurlaila, N., Purnomo, E., & Aziz, N. (2023). Technological Pedagogical and Content Knowledge (TPACK) in Islamic religious education in the digital era. *Al Hikmah: Journal of Education*, *4*(1), 93-106.

Hoesny, M. U., Setyosari, P., Praherdhiono, H., & Suryati, N. (2024). Integrating digital technology into project-based learning: Its impact on speaking performance. *Mextesol Journal*, *48*(3), 1-11.

Huong, T. T., Vy, P. N. T., Minh, L. H., & Linh, N. T. (2025). Primary school teacher educators' digital competence: Perceived confidence and continuing needs for 21st-century teaching. *Educational Process: International Journal, 15*(1) 1-23.

Hussain, T., & Jamil, I. (2024). Investigating the relationship between pre-service teachers' cognitive flexibility and techno-pedagogical competencies: A pathway to effective teaching in the digital age. *Annals of Human and Social Sciences*, *5*(4), 220-229.

Ibda, H., Febriani, N. R., Al Hakim, M. F., Faizah, S. N., Wijanarko, A. G., & Qosim, N. (2022). Game innovation: A case study using the Kizzugemu visual novel game with Tyranobuilder software in elementary school. *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS), 28*(1), 460-469.

Ibda, H., Syamsi, I., & Rukiyati, R. (2023). Professional elementary teachers in the digital era: A systematic. *International Journal of Evaluation and Research in Education (IJERE), 12*(1), 459-467.

Ibrohim, I., Muksar, M., Yulianti, E., Sumberartha, I. W., & Hajar, M. U. Development of the insightful educatorhub platform to enhance technology-based mentoring collaboration in the teacher professional education program. *Paedagogia*, *27*(3), 357-367.

Ikhsan, I., Husnaini, A. N., & Lopo, F. L. (2025). Strategies for implementing ai in LMS to improve the effectiveness and personalization of digital learning. *The Journal of Academic Science*, *2*(3), 944-953.

Ismail, M., Zubair, M., Alqadri, B., & Basariah, B. (2023). Integration of technological pedagogical and content knowledge in 21st Century learning. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2363-2367.

Jalaluddin, J. (2024). Strategi guru dalam meningkatkan kemampuan literasi digital siswa. *Analysis, 2*(1), 171-178.

Jay, L. P. (2023). What do social studies methods instructors know and do? Teacher educators' PCK for facilitating historical discussions. *Theory and Research in Social Education, 51*(1), 72-99.

Kamali, J., & Javahery, P. (2025). Collaborative reflection as a means to improve teachers' reflective skills: A community of practice perspective. *Reflective Practice*, *26*(2), 246-261.

https://doi.org/10.17509/curricula.v4i1.84679

Khan, S., Ahmed, R. R., Streimikiene, D., Streimikis, J., & Jatoi, M. A. (2022). The competency-based training and assessment, and improvement of technical competencies and changes in pedagogical behavior. *E and M Ekonomie a Management*, *25*(1), 96-112.

Kiryakova, G., & Kozhuharova, D. (2024). The digital competences necessary for the successful pedagogical practice of teachers in the digital age. *Education Sciences, 14*(5), 1-19.

Kusuma, R. D. (2025). The impact of interactive media based on augmented reality on elementary school students' learning motivation. *Journal of the American Institute*, *2*(1), 40-48.

Li, Z., & Zhang, W. (2025). Technology in education: Addressing legal and governance challenges in the digital era. *Education and Information Technologies*, *30*(7), 8413-8443.

Listiyoningsih, S., Hidayati, D., & Winarti, Y. (2022). Strategi guru menghadapi transformasi digital. *Jurnal Ilmiah Profesi Pendidikan, 7*(2b), 655-662.

Masrur, M. (2021). Digital leadership to improve the pedagogical competence of university English lecturers in Samarinda. *Journal of Social Studies Education Research, 12*(4), 424-446.

Mukhlis, H., Haenilah, E. Y., Maulina, D., & Nursafitri, L. (2024). Connectivism and digital age education: Insights, challenges, and future directions. *Kasetsart Journal of Social Sciences*, *45*(3), 803-814.

Mukul, E., & Büyüközkan, G. (2023). Digital transformation in education: A systematic review of education 4.0. *Technological Forecasting and Social Change*, *194*(5), 1-10.

Murkatik, K., Harapan, E., & Wardiah, D. (2020). The influence of professional and pedagogic competence on teacher's performance*. Journal of Social Work and Science Education, 1*(1), 58-69.

Nermend, M., Singh, S., & Singh, U. S. (2022). An evaluation of decision on paradigm shift in higher education by digital transformation. *Procedia Computer Science, 207*(1), 1959-1969.

Novida, N. A. N. F. (2025). Transformation of early childhood education teachers competencies in the digital era: A literature study on training needs in 2025. *International Journal of Teaching*, *2*(1), 1-8.

Novita, L., Windiyani, T., & Sofyan, D. (2022). Teacher professional development as an effort to improve TPACK skills in 21st century learning. *Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar (JPPGuseda)*, *5*(3), 97-100.

Novriyanto, E., Harsani, P., & Hardhienata, S. (2025). Peningkatan kompetensi professional guru di era digital melalui pengembangan pelatihan berbasis artificial intelligence dan blended learning. *Wawasan: Jurnal Ilmu Manajemen, Ekonomi dan Kewirausahaan*, *3*(2), 20-25.

Nugraha, S. A., Sudiatmi, T., & Suswandari, M. (2020). Studi pengaruh daring learning terhadap hasil belajar Matematika kelas IV. *Jurnal Inovasi Penelitian, 1*(3), 265-276.

https://doi.org/10.17509/curricula.v4i1.84679

Nurabadi, A., Suhariadi, F., Mardiyanta, A., Triwiyanto, T., & Adha, M. A. (2022). Digital principal instructional leadership in new normal era. *International Journal of Evaluation and Research in Education, 11*(3), 1090-1098.

Orakova, A., Nametkulova, F., Issayeva, G., Mukhambetzhanova, S., Galimzhanova, M., & Rezuanova, G. (2024). The relationships between pedagogical and technological competence and digital literacy level of teachers. *Journal of Curriculum Studies Research, 6*(1), 1-21.

Patiño, A., Ramírez-Montoya, M. S., & Buenestado-Fernández, M. (2023). Active learning and education 4.0 for complex thinking training: Analysis of two case studies in open education. *Smart Learning Environments*, *10*(8), 1-21.

Polly, D., Martin, F., & Byker, E. (2023). Examining pre-service and in-service teachers' perceptions of their readiness to use digital technologies for teaching and learning. *Computers in the Schools, 40*(1), 22-55.

Qadeer, A., Shahid, S. H., & Ullah, N. (2024). Effect of teacher competency and classroom environment on students' academic achievement in secondary schools. *Journal of Excellence in Social Sciences*, *3*(1), 74-86.

Raihan, S., & Nurzalkinah, S. (2024). Tantangan penggunaan teknologi dalam pembelajaran di era society 5.0. *Nubin Smart Journal, 4*(1), 1-9.

Ranta, S., Kangas, J., Harju-Luukkainen, H., Ukkonen-Mikkola, T., Neitola, M., Kinos, J., ... & Kuusisto, A. (2023). Teachers' pedagogical competence in finnish early childhood education—a narrative literature review. *Education Sciences, 13*(8), 1-15.

Rintayati, P., & Syawaludin, A. (2022). An investigation of the main characteristics of science teachers in elementary schools who have digital pedagogical skills. *Pegem Journal of Education and Instruction, 12*(4), 161-168.

Robandi, B., Setiawardani, W., & Apriyanto, A. (2025). Factors influencing the pedagogical competence of elementary school teachers in the digital era: A survey study. *Journal of General Education and Humanities*, *4*(2), 561-574.

Rumiantseva, K., Yevdokymova, N., Bratushka, S., Kharchenko, N., & Iievliev, O. (2023). The importance of multimedia means usage in improving the quality of education. *Cadernos de Educação Tecnologia e Sociedade*, *16*(3), 665-674.

Sari, N. M., Yaniawati, P., Firmansyah, E., Mubarika, M. P., Assegaff, N., & Purwanti, N. S. A. (2023). Pelatihan pembuatan storyboard dan games interaktif untuk guru dan mahasiswa magister pendidikan Matematika. *Transformasi: Jurnal Pengabdian Masyarakat, 19*(1), 153-166.

Sastypratiwi, H., & Nyoto, R. D. (2020). Analisis data artikel sistem pakar menggunakan metode systematic review. *Jurnal Edukasi dan Penelitian Informatika*, *6*(2), 250-257.

Sele, Y., & Dewi, N. P. Y. A. (2025). Challenges and opportunities in preparing prospective teachers in the digital era: A critical study based on digital literacy profile. *Jurnal Eduscience*, *12*(2), 524-552.

Somantri, D. (2021). Abad 21 pentingnya kompetensi pedagogik guru. *Equilibrium: Jurnal Penelitian Pendidikan dan Ekonomi, 18*(2), 188-195.

https://doi.org/10.17509/curricula.v4i1.84679

Sudorová, J., Záhorec, J., & Hašková, A. (2025). Innovations in the education of future teachers: Integration of digital didactic tools in the training of primary education teachers. *R and E-Source, 1*(1), 338-351.

Sümer, M. (2021). Online learning communities in teachers' professional development: A systematic review. *Anadolu Journal of Educational Sciences International*, *11*(2), 572-587.

Supkhonovna, H. N. (2021). Technology for the development of the qualities of pedagogical competence in future teachers. *Asian Journal of Multidimensional Research, 10*(5), 372-382.

Tang, Q., Kamarudin, S., Rahman, S. N. A., & Zhang, X. (2025). Bridging gaps in online learning: A systematic literature review on the digital divide. *Journal of Education and Learning*, *14*(1), 161-176.

Umarovich, K. S., & Ollaberganovna, S. F. (2025). Technology for developing sociocultural competence of future science teachers. *American Journal of Education and Learning*, *3*(1), 525-540.

Utomo, F. T. S. (2023). Inovasi media pembelajaran interaktif untuk meningkatkan efektivitas pembelajaran era digital di sekolah dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 8*(2), 3635-3645.

Van Laar, E., Van Deursen, A. J., Van Dijk, J. A., & De Haan, J. (2020). Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review. *Sage Open, 10*(1), 1-14.

Wijayanti, A., Dwiningrum, S. I. A., & Saptono, B. (2024). Digital literacy in elementary schools post COVID-19: A systematic literature review. *International Journal of Learning, Teaching and Educational Research*, *23*(12), 96-112.

Winantika, E. Y., Febriyanto, B., & Utari, S. N. (2022). Peran media sosial dalam pembentukan karakter siswa di era digital. *Jurnal Lensa Pendas, 7*(1), 1-14.

Xolbayeva, D. A. (2025). Modern methods of forming pedagogical competencies in future teachers. *EduVision: Journal of Innovations in Pedagogy and Educational Advancements*, *1*(3), 24-38.

Yurna, Y. (2023). Kompetensi profesional guru terhadap penguasaan teknologi informasi di SMK Yasti 1 Cisaat Sukabumi. *Sanskara Pendidikan dan Pengajaran, 1*(3), 126-133.

https://doi.org/10.17509/curricula.v4i1.84679