

PREPARING TECHNOLOGY-LITERATE TEACHERS: A STRATEGY FOR IMPROVING ICT COMPETENCE BASED ON SYSTEMATIC LITERATURE STUDY

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Article Info

Article history:

Received May 15, 2026

Revised June 18, 2026

Accepted June 26, 2026

Keywords:

ICT competence, technology-literate teachers, capacity building strategy, library research, digital education transformation.

ABSTRACT

Teacher competence in Information and Communication Technology (ICT) is a key pillar of digital education transformation. However, studies show that the digital literacy gap among educators remains a systemic challenge in developing countries, including Indonesia, due to generational differences, infrastructure limitations, and the absence of measurable ICT standards. This study aims to formulate strategies for improving teacher ICT competence based on a synthesis of recent literature. Using library research with a systematic approach to indexed journals (2023–2026) and textbooks (2018–2026), data were analysed through thematic content analysis and narrative synthesis. Findings reveal four strategic pillars: locally adapted UNESCO CFT frameworks; sustainable andragogical and micro-learning training; digital communities of practice with peer mentoring; and incentive systems integrated with project-based digital portfolios. Key barriers include technostress among senior teachers, lack of institutional support, and urban-rural infrastructure disparities. The main contribution of this research is providing an integrated, evidence-based strategic model for enhancing teacher ICT competence that bridges policy, practice, and local context in developing countries. The study concludes that strategies must be holistic and contextual. Policy recommendations include measurable competency standards, sustainable budgets, and community-based online professional development platforms.

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INTRODUCTION

The digital revolution has fundamentally changed the nature of the teaching profession. While in previous eras teachers simply needed to master basic content and pedagogy, now the demand for information and communication technology (ICT) competency has become a non-negotiable necessity. The COVID-19 pandemic drastically accelerated this acceleration, forcing millions of teachers worldwide to make the digital leap in a matter of weeks (Suryani & Hamidah, 2023). The concept of a "tech-literate teacher" is no longer understood simply as being able to use a computer or the internet, but also encompasses the ability to pedagogically integrate ICT into learning design, evaluate learning processes based on digital data, and apply ethics and cybersecurity in educational interactions .

However, various studies in the past three years have revealed alarming facts. A cross-country survey by the OECD (2024) showed that the average teacher in developing countries only mastered around 45% of the minimum required ICT competencies. In Indonesia, the results of the 2025 National Assessment indicated that only 36% of teachers felt confident using ICT for interactive learning, while in 3T (frontier, outermost, and disadvantaged) regions, this figure dropped to 14% (Pusmendik, 2025). Furthermore, the intergenerational gap is evident: teachers with more than 20 years of service tend to experience technostress and resistance, while millennial and Gen Z teachers often use technology instrumentally without pedagogical depth (Haryanto & Putri, 2026).

Various interventions have been implemented, ranging from synchronous online training and intensive offline workshops to the provision of hardware. However, evaluations of these programs consistently show low long-term effectiveness. A meta-analysis by Fernández-Gutiérrez et al. (2023) found that over 60% of ICT training programs for teachers failed to produce sustainable changes in teaching practices after six months. This failure was largely due to a one-size-fits-all approach, failure to consider individual teacher profiles, and the absence of ongoing mentoring and feedback mechanisms.

This is where the urgency of this research lies. A comprehensive synthesis of the current literature is needed to formulate evidence-based strategies for improving teachers' ICT competencies. This research uses a library research approach with the main objectives: (1) identifying and analyzing various strategies for improving teachers' ICT competencies proposed in the 2023-2026 literature, (2) formulating an integrative strategic framework that is appropriate to the Indonesian educational context, and (3) mapping the obstacles and supporting factors for the successful implementation of these strategies. The significance of this research is the availability of a theoretical roadmap that can serve as a reference for policy makers, teacher training institutions, and future researchers in designing more effective ICT competency improvement interventions.

LIBRARY REVIEW

Teacher ICT Competence : Definition and Theoretical Framework

ICT competencies in the context of the teaching profession are authoritatively defined by UNESCO through the ICT Competency Framework for Teachers (CFT) version 3.0, published in 2018 and continuously updated. This framework divides competencies into three levels (technology literacy, knowledge deepening, knowledge creation) and six dimensions: basic understanding of ICT, utilization of digital resources, ICT-based pedagogy, digital assessment, digital ethics and security, and continuous professional development. This framework has been adopted by more than 70 countries as a reference standard for digital competencies for teachers. In the Indonesian context, Minister of Education, Culture, Research, and Technology Regulation No. 9 of 2022 concerning Teacher Competency Standards implicitly mentions digital literacy as part of pedagogical and professional competencies, but its operational indicators are still general. Indonesian scientists then developed it further. Santosa & Wijaya (2025) proposed an ICT competency model for Indonesian teachers consisting of five domains: basic digital operation, digital teaching design, digital assessment, digital communication and collaboration, and digital ethics and safety. This model has been tested for validity involving 1,200 teachers in Java. Meanwhile, Nugroho & Lestari (2023) found that age and teaching

experience were negatively correlated with ICT competency, while frequency of social media use was positively but weakly correlated with digital pedagogical competency.

Strategy for Improving ICT Competence in Literature

The literature on teacher professional development in the ICT domain has undergone significant evolution in the past five years. While previously dominated by short-term, face-to-face training models, a consensus is now emerging that sustainable and contextual approaches are more effective. Knowles (1984), through his andragogy theory, established the principle that adults learn effectively when: (1) the material is relevant to practical needs, (2) they are involved in lesson planning, and (3) life experiences serve as learning resources. These principles were further developed by Suryani & Hamidah (2023) in the context of digital teacher training. They emphasized the importance of autonomy, relevance, and practicality in each training module .

One of the approaches that received the most attention in the literature between 2023 and 2026 was microlearning. This approach presents material in small units (5-15 minutes) that can be accessed flexibly. Rahman et al. (2025) in a randomized controlled trial in Malaysia demonstrated that teachers who participated in ICT training in a microlearning format had a higher retention rate (82%) than those who participated in a conventional lecture format (43%) after 4 months. In Indonesia, Susilowati & Prihartini (2024) found that microlearning combined with automated reminders via WhatsApp increased teacher engagement by up to three times compared to traditional synchronous training .

The second approach is digital communities of practice and peer mentoring . Handayani et al. (2024) examined in depth how Telegram and WhatsApp-based communities can provide safe spaces for senior teachers who feel shy about asking questions in public forums. Their digital ethnographic research showed that in small groups of 8-12 teachers, there is a more intensive transfer of knowledge, particularly from junior teachers to senior teachers on technical matters, and vice versa from senior teachers to junior teachers on content pedagogy. This model is often referred to as reverse mentoring or reciprocal mentoring.

The third approach is project- based training and digital portfolios. Teachers are not only exposed to theory but also asked to develop tangible digital products (learning videos, interactive quizzes, multimedia teaching materials), which are then assessed and uploaded to the institution's repository. Rahmawati et al. (2024) found that teachers who went through this process had a higher sense of ownership and confidence in integrating ICT into the classroom than those who simply attended training without a final product.

Barriers to Strategy Implementation

The literature also consistently identifies several key barriers. First, individual barriers in the form of technostress and digital anxiety. Haryanto & Putri (2026) revealed that teachers over 45 years of age tend to have significant levels of digital anxiety, which , if left unaddressed, can trigger permanent resistance. Second, institutional barriers: lack of support from the principal, lack of dedicated learning time, and the absence of formal incentives for teachers to improve their ICT competencies. Third, infrastructure barriers: disparities in internet access and devices between urban and rural areas remain a harsh reality in many developing countries.

RESEARCH METHODS

This study uses a library research approach with a systematic design. This method was chosen because the research objective is to synthesize existing knowledge, identify patterns, gaps, and consensus in the literature, and formulate an integrative strategy based on the latest evidence .

Data Sources : The primary data of this study are relevant written documents , consisting of: (1) scientific journal articles published between 2023 and April 2026, (2) textbooks or monographs published between 2018 and 2026, both by Indonesian and international scientists, and (3) official policy documents, including reports from UNESCO, OECD, and the Ministry of Education, Culture, Research, and Technology. Inclusion criteria: (a) direct relevance to the topic of teacher ICT competency or strategies for increasing the digital capacity of educators, (b) using a credible methodology (rigorous empirical or theoretical studies), (c) published in Indonesian or English. Exclusion criteria: opinion articles without data, non-peer-reviewed conference proceedings, and literature before 2018 except for fundamental works (e.g., Knowles, 1984; Vygotsky, 1978).

Collection Procedure : Literature search was conducted through indexed databases (Scopus, Web of Science, Google Scholar, Garuda, and Sinta). Keywords used in various combinations include: "teacher ICT competence", "technology literate teachers", "ICT capacity building strategies", "digital competence of teachers", "teacher professional development ICT", "ICT competency framework", "micro-learning teacher", "digital peer mentoring". The search process resulted in 384 potential articles, which after going through the screening process of titles, abstracts, and full texts, left 47 journal articles and 12 books that met the criteria .

Data Analysis : The analysis technique used was thematic content analysis followed by narrative synthesis. The process included: (1) re-reading the entire text, (2) identifying units of meaning, (3) coding these units into initial categories, (4) grouping categories into main themes, (5) looking for relationships between themes, and (6) formulating a final synthesis. To ensure reliability, peer debriefing was conducted with two other researchers who were not directly involved in the analysis to test the consistency of thematic interpretations.

RESEARCH RESULT

Based on a synthesis of 47 journal articles (2023-2026) and 12 books (2018-2026), this study identified four main themes of strategies for improving teachers' ICT competencies, as well as three main groups of obstacles .

ICT Competency Improvement Strategy : Four Integrative Pillars

Pillar 1: Development of an Adaptive and Measurable Competency Framework .

The literature agrees that strategies for improving ICT competency must begin with accurate mapping. The UNESCO CFT framework (2018) serves as a primary reference, but needs to be adapted to local contexts. Haryanto & Putri (2026) developed the Indonesian Teacher Digital Literacy Index (ILDGI) with 28 indicators that have been piloted nationally. They found that without an accurate baseline assessment, training programs often miss the mark (e.g., the material is too basic for young teachers or too advanced for senior teachers). Meanwhile, Santosa & Wijaya (2025) emphasize the importance of distinguishing between the minimum competencies all teachers must possess and the advanced competencies required for teachers to act as agents of digital change .

Pillar 2: Andragogy and Micro-learning Training Models.

Nearly all recent literature criticizes the 1-3 day crash training model. Instead, the spaced learning model with a micro-learning approach has become the consensus. Rahman et al. (2025) showed that 5-10 minute modules accessed 2-3 times per week for 12 weeks resulted in better competency gains (effect size $d=0.89$) than conventional 3-day training ($d=0.31$). In Indonesia, a trial by Susilowati & Prihartini (2024) using an LMS platform integrated with WhatsApp resulted in a module completion rate of 91%, far above the 47% achieved on conventional e-learning platforms.

Pillar 3: Digital Communities of Practice and Peer Mentoring.

This theme emerges most consistently in the qualitative literature. Handayani et al. (2024) identified that the success of improving ICT competency in rural areas is largely determined by the presence of local facilitators who can provide intensive mentoring. The peer mentoring model developed by Nugroho & Lestari (2023) involves junior-senior teacher pairs exchanging expertise (reciprocal mentoring) and has been shown to increase senior teachers' confidence in using ICT by up to 67% within 3 months.

Pillar 4: Project-Based Incentive and Portfolio System .

Without recognition and incentives , it is difficult to expect teachers to invest extra time in learning ICT. Rahmawati et al. (2024) proposed a digital micro-credentials system where teachers receive digital badges for each competency they master, which can be converted into credit points for promotion. This model has been piloted by the Education and Training Center (Pusmendik) (2025) in three provinces with positive results: teacher participation in ICT training increased by 220% after the credit point incentive was announced.

Main Obstacles and Supporting Factors

The three main barriers consistently identified by the literature are: first, individual factors: technostress (digital anxiety), low self-efficacy, and resistance to change. Haryanto & Putri (2026) found that teachers with high technostress tend to avoid online training. Second, institutional factors: excessive workload, lack of principal support, and the absence of scheduled collaboration. Third, infrastructure factors: unequal internet access, especially in

rural and 3T areas. Meanwhile, the most decisive supporting factors for success are: (1) the principal's commitment, (2) the availability of accompanying facilitators, and (3) the existence of special time (protected time) for teachers to study.

Discussion

The findings of this study confirm that improving teachers' ICT competency is not merely a technical issue, but rather a systemic one involving psychological, social, organizational, and infrastructural dimensions. The four identified pillars cannot stand alone; integration between them is essential for success .

Integrate competency frameworks with training . Without a clear framework, training tends to be random and unfocused. However, frameworks like the UNESCO CFT should not be simply imported. Indonesian scholars such as Santosa & Wijaya (2025) have demonstrated that several indicators in the CFT need to be simplified to reflect the current average level of digital literacy in Indonesian teachers. In this regard, a phase-in approach is more realistic than directly targeting the level of knowledge creation.

The advantages of microlearning for teachers with limited time . Teachers in Indonesia typically teach 24 hours per week, plus administrative duties, making it difficult to set aside time for extensive training. Microlearning addresses this challenge. However, the literature also warns that microlearning is only effective if supported by reminder systems and progress tracking. Without these , dropout rates can be high .

The crucial role of communities of practice . The most interesting finding is that long-term success is determined more by social support than by the quality of the training materials themselves. Handayani et al. (2024) explain this phenomenon with social capital theory: teachers connected in supportive networks tend to adopt innovations more quickly. WhatsApp or Telegram communities that initially focused solely on file sharing have evolved into technical and psychological consultation spaces. This suggests that strategies for improving ICT competency must consider affective and relational aspects , not just cognitive ones .

Incentives : a solution or a new problem ? Providing credit incentives for ICT training does encourage participation, but the literature also warns of the risk of gaming the system (teacher participation in training solely for certification, without any real change in practice). Rahmawati et al. (2024) propose a solution by requiring a digital portfolio as a condition for receiving incentives. This way, incentives are linked to output and outcomes, not simply attendance.

Research limitations . As a literature study, this study has the limitation that it did not directly test these strategies in the field. However, its strength lies in its comprehensive synthesis of the best available evidence as of 2026. Future research is recommended to conduct field trials of the formulated integrative strategies.

CONCLUSION

This study concludes that improving educators' ICT competencies requires a holistic, systematic, and sustainable approach. Based on a 2023–2026 literature review, the best strategy includes four pillars: (1) developing an adaptive competency framework accompanied by appropriate diagnostic assessments, (2) andragogy-based training using micro-learning

methods, (3) establishing a digital community of practice supported by reciprocal peer mentoring, and (4) implementing an incentive system through a digital portfolio. All four pillars must be implemented simultaneously because separate implementations have proven ineffective. Key barriers include technostress among senior teachers, minimal institutional support, and digital infrastructure gaps.

For policy makers and education practitioners, it is recommended: (1) to use the Indonesian Teacher Digital Literacy Index (ILDGI) for national mapping, (2) to shift the budget from mass training to sustainable community-based mentoring, (3) to include teacher digital portfolios in the Teacher Performance Assessment (PKG) system, and (4) to provide a digital professional development platform that supports micro-learning, discussions, and micro-credentials. For further researchers, it is recommended to conduct field trials of this integrative strategy using randomized controlled trials in various regions (urban, rural, underdeveloped, frontier, outermost areas) to measure its comparative effectiveness.

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