Teacher Competence Development Management in the Era of Artificial Intelligence: A Strategic Framework for Elementary School Teachers

Aan Fadia Annur
Universitas Islam Negeri K.H. Abdurrahman Wahid Pekalongan, Indonesia
E-mail: aan.fadia.annur@uingusdur.ac.id

Dian Rif'iyati
Universitas Islam Negeri Walisongo, Semarang, Indonesia
E-mail: 23090290111@student.walisongo.ac.id

Diva Valencia Zahra
Universitas Islam Negeri K.H. Abdurrahman Wahid Pekalongan, Indonesia
E-mail: diva.valencia.zahra25201@mhs.uingusdur.ac.id

Nafa Adilla
Universitas Islam Negeri K.H. Abdurrahman Wahid Pekalongan, Indonesia
E-mail: nafa.adilla25008@mhs.uingusdur.ac.id

Abstract

The advancement of Artificial Intelligence (AI) has transformed the professional competency requirements for teachers while simultaneously presenting new challenges for human resource management in primary schools. It is no longer sufficient for teachers to possess merely pedagogical, professional, social, and personality competencies; they now require the ability to understand, select, evaluate, and utilize AI in ways that are pedagogically sound, critical, ethical, and learner-oriented. This article aims to analyze the need for teacher competency development in the AI era and to formulate a strategic framework for managing such development in primary schools. The study employs an integrative literature review approach, examining literature on teachers' digital competence, AI literacy, AI-TPACK, teachers' AI competence, professional development, and educational human resource management. The literature was analyzed thematically to identify shifting competency demands and corresponding development strategies. The findings indicate that teacher competency development in the AI era encompasses six domains: AI knowledge, AI-pedagogy integration, AI-assisted assessment, ethics and security, a human-centered approach, and continuous professional engagement. Based on this synthesis, the article proposes a strategic framework comprising six stages: competency needs analysis, competency mapping, development planning, practice-based professional learning, mentoring and learning communities, and monitoring, evaluation, and continuous improvement. This framework positions school principals and the school organization as managers of a competency development ecosystem, rather than mere providers of training.

Consequently, the management of teacher competency development in the AI era must aim to cultivate teachers who are adaptable to technology, capable of making critical pedagogical decisions, aware of ethical risks, and committed to maintaining human relationships as the core of education.
Keywords: teacher competency management, artificial intelligence, professional development, primary school

Introduction

Digital transformation has reshaped the work environment within educational organizations. The advancement of Artificial Intelligence (AI) has accelerated this shift, as the technology is employed not only for automating administrative tasks but also for lesson planning, instructional material development, assessment, feedback provision, information retrieval, and teacher professional development. Systematic reviews indicate that AI in education is evolving across various functions, making the human competencies required to use and control this technology a matter of strategic importance (Wang et al., 2024). These changes have direct implications for the teaching profession. Primary school teachers face the challenge of understanding AI technology while ensuring its application aligns with educational goals, learner characteristics, and ethical principles. Celik et al. (2022) highlight that while AI offers numerous opportunities for teachers, its implementation also presents challenges regarding competence, trust, ethics, and shifting professional roles.

The concept of teacher digital competence has also expanded. Digital competence is no longer confined to the ability to operate devices, use applications, or access digital resources. Teachers must possess the ability to select appropriate technologies, evaluate digital information, and utilize technology in creative, safe, critical, and responsible ways. A systematic review by Smestad et al. (2023) reveals that teacher digital competence comprises multiple dimensions, with ongoing diversity in how it is defined and measured. In the context of AI, these requirements have evolved into the concepts of AI literacy and AI competence. Sperling et al. (2024) indicate that while AI literacy in teacher education is a growing field, the associated competency frameworks are still under development. Similarly, Mikeladze et al. (2024) identified various AI competency frameworks for educators, each with a different orientation. These findings suggest that developing teachers' AI competence cannot be achieved solely through one-off technical training sessions.

These shifting competency demands require a response through the management of teacher competency development. From a human resource management perspective, competency development is a strategic process encompassing needs identification, planning, implementation, mentoring, evaluation, and improvement. Consequently, the rise of AI should not be viewed merely as an issue of instructional technology, but as a factor transforming the needs and strategies for developing educational human resources. The primary school context possesses unique characteristics; teachers engage with students who are still in stages of cognitive, social, emotional, and moral development that require direct interaction and intensive guidance. Therefore, AI competency among primary school teachers cannot be measured solely by the number of applications they can use. More critical is the teacher's ability to determine

when AI use is relevant, how AI outputs are verified, how student data is protected, and how technology remains positioned as a tool to reinforce human-centered learning.

Research in Indonesia also indicates that the development of teachers' digital competencies is not influenced solely by individual factors. Bentri et al. (2022) highlight the importance of various supporting factors in developing the digital pedagogical competencies of primary education teachers. These findings reinforce the view that teacher competencies evolve within an organizational environment that provides support, resources, learning opportunities, and leadership. Teacher professional development must also be aligned with the characteristics of AI. Through a systematic review, Dogan et al. (2025) demonstrate the importance of integrating AI with technological and pedagogical knowledge within professional development programs. Brandão et al. (2024) emphasize that professional development addressing generative AI must provide opportunities for teachers to gain practical experience, build AI literacy, collaborate, and reflect on the use of AI in educational practice.

Based on this premise, this article focuses on the management of teacher competency development. AI is positioned as a strategic environmental shift requiring schools to adjust their human resource development systems. The article aims to: (1) identify changing competency requirements for primary school teachers in the AI era; (2) analyze principles and strategies for managing teacher competency development; and (3) formulate a strategic framework for managing teacher competency development that can serve as a basis for professional development management in primary schools.

Methods

This study employs an integrative literature review approach. This approach was selected because the research objective goes beyond merely counting or classifying prior research results; instead, it aims to integrate conceptual and empirical findings to synthesize insights regarding the management of teacher competency development in the AI era. The literature search focused on scholarly publications addressing Artificial Intelligence in education, AI literacy, AI competence, teacher digital competence, AI-TPACK (or Intelligent-TPACK), teacher professional development, and the development of educational human resources. The sources include international and national journal articles that are academically retrievable and, wherever possible, possess a DOI.

Inclusion criteria were as follows: (1) the literature addresses teacher competence, AI literacy, digital competence, AI integration in pedagogy, or professional development; (2) it is relevant to school education or teacher education; (3) it explains the implications of AI or digital technology for teacher professionalism and competence; and (4) it provides information useful for formulating managerial implications. Literature focusing solely on the technical aspects of AI algorithm development without a connection to teachers and education was excluded from the scope.

The analysis was conducted in three stages. The first stage involved identifying the key concepts and findings of each source. The second stage entailed categorizing findings into themes: changing competency demands, AI-TPACK, AI ethics, professional development, organizational support, and competency management. The third stage involved a thematic synthesis to construct a strategic framework for teacher competency development. This synthesized framework was then analyzed against human resource development management functions: needs analysis, planning, development, implementation, mentoring, evaluation, and

continuous improvement. Through this approach, the article addresses not only the competencies required by teachers but also how schools can manage the development process.

Results

Shifting Demands for Teacher Competence in the AI Era

Research findings indicate a shift from digital competence to more complex AI competence. In the initial phase of digital transformation, teacher competence primarily centered on the ability to use digital tools and resources. The advancement of AI has expanded these demands to include understanding how AI works and its limitations, evaluating AI outputs, integrating AI with pedagogy, and managing ethical risks.

Chiu et al. (2025) identified six dimensions of teacher AI competence: AI knowledge, AI pedagogy, AI assessment, AI ethics, human-centered education, and professional engagement. This framework demonstrates that AI competence cannot be reduced to mere technical skills.

Table 1 Teacher Competencies in the AI Era

Evolving Competencies	Demands in the AI Era
Digital literacy	AI literacy, data literacy, and understanding the limitations of AI systems
Use of technology	Selection, evaluation, verification, and purposeful use of AI
Lesson planning	Pedagogically sound design of AI-supported learning
Teaching material development	Curation and verification of AI-generated content
Assessment	Use of AI to support assessment, accompanied by teacher validation
Professional ethics	Privacy, data security, bias, transparency, integrity, and accountability
Professional development	Continuous and collaborative professional learning

Competency Dimensions Requiring Development

First, AI knowledge: a foundational understanding of the concepts, capabilities, limitations, and characteristics of AI systems. Teachers need not be programmers, but they must understand how to critically evaluate AI outputs. Second, AI pedagogical competence: the ability to integrate AI with learning objectives, learner characteristics, subject matter, instructional strategies, and the classroom context. Third, AI assessment competence: the ability to use AI to support the assessment process while verifying the accuracy, validity, and appropriateness of AI outputs; teachers remain the professional decision-makers. Fourth, AI ethical competence: the ability to understand issues regarding privacy, data security, algorithmic bias, plagiarism, academic integrity, and the risks of AI dependency. Fifth, human-centered competence: the ability to ensure that AI usage enhances—rather than replaces—pedagogical interactions and human decision-making. Sixth, professional engagement: the teacher's involvement in continuous professional learning, sharing of practices, reflection, and competency development.

AI-TPACK as a Basis for Competence Development

Literature indicates that integrating AI into instruction requires a blend of technological, pedagogical, and content knowledge. Through the concept of Intelligent-TPACK, Celik (2023) emphasizes that effective and ethical AI integration necessitates an interplay among technological, pedagogical, and content knowledge, alongside ethical considerations. Ning et al. (2024) also demonstrate the interrelationships among AI-TPACK components within teachers' professional knowledge. These findings imply that teacher training should not focus on mastering specific applications in isolation, but rather on how AI connects with pedagogical needs and instructional content.

The Need for Continuous Professional Development

Dogan et al. (2025) indicate that AI-based professional development programs need to link technological knowledge with pedagogy. Brandão et al. (2024) also identify AI literacy, practical experience, collaboration, and reflection as essential elements of professional development in the context of generative AI. These findings suggest that one-off workshops are inadequate as a primary strategy. Competence development requires a professional learning cycle: understanding concepts, experimenting, applying knowledge, receiving feedback, reflecting, and refining practice.

Organizational Factors in Teacher Competence Development

Teacher competence develops within an organizational context. Bentri et al. (2022) highlight the importance of supporting factors in the development of digital pedagogical competence among primary education teachers. School support can take the form of infrastructure provision, access to learning resources, time for learning, leadership, learning communities, and technology usage policies. Therefore, the management of teacher competence development needs to view the school as a professional learning ecosystem. Principals should not merely provide training but also create organizational conditions that enable teachers to develop their competence and apply it in a sustainable manner.

Discussion

Shifting competency requirements indicate that AI is a strategic factor in school human resource management. Schools need to identify the new competencies required, compare them with teachers' actual competencies, and design appropriate development interventions. In a competency-based human resource management approach, teacher development begins with organizational needs. Consequently, the primary question is not merely which AI technologies are currently trending, but rather what competencies schools require for teachers to perform their professional duties effectively in an AI-influenced environment. Mikeladze et al. (2024) demonstrate that AI competency frameworks for educators vary widely. This offers schools the opportunity to adapt competency frameworks to suit the primary school context, teacher characteristics, subject areas, and student needs.

Based on a synthesis of the literature, this article proposes a six-stage strategic framework as follows: 1) Competence needs analysis. Schools map needs based on AI developments, teacher task requirements, student characteristics, and school priorities. 2) Teacher competence mapping. Schools identify teachers' AI proficiency levels across aspects such as knowledge, pedagogy, assessment, ethics, human-centered education, and professional engagement. 3) Development planning. Mapping results are used to determine priorities for training, mentoring, learning communities, resources, and success indicators. 4) Practice-based professional learning. Development programs focus on real-world experiences, such as designing instructional materials, creating assessments, evaluating AI outputs, and solving instructional problems. 5) Mentoring and learning communities. Teachers engage in coaching, peer review, discussions on best practices, and reflection on their experiences using AI. 6) Monitoring, evaluation, and improvement. Schools assess competence development, implementation

quality, ethical risks, and the impact on instructional practices. Evaluation results are used to update development needs.

The framework positions the school principal as the manager of the competency development ecosystem. The principal acts as a strategic planner in identifying competency needs; a facilitator in providing resources and learning opportunities; a learning leader in fostering a culture of learning; a policy maker in establishing AI governance; and an evaluator in monitoring teachers' competency development. The principal need not be the school's most expert AI user. A more critical role is ensuring the organization possesses the direction, systems, resources, and culture that enable teachers to learn and utilize AI responsibly.

A significant implication of this study is the need to redesign training programs. Training that merely introduces AI application features tends to yield skills that are merely instrumental in nature. Conversely, competency development must link technology with real-world instructional challenges. Training can employ a cycle comprising understanding AI, experimenting with AI, designing instruction, implementation, evaluation, and reflection. This approach aligns with findings regarding the importance of integrating AI and pedagogy within professional development (Dogan et al., 2025).

The rapid evolution of AI necessitates continuous updating of technological knowledge. Consequently, schools need to establish professional learning communities that enable teachers to learn collaboratively. Teachers can share experiences, evaluate AI outputs, conduct peer reviews of instructional materials, and discuss ethical issues. Coaching complements formal training; such mentorship allows teachers to receive support while applying competencies in real classroom settings. This strategy transforms competency development from a one-off activity into a process of continuous professional learning.

AI competency must be accompanied by ethical competence. Chiu et al. (2025) identify AI ethics and human-centered education as crucial dimensions of teachers' AI competency. In the primary school context, these principles are particularly relevant, as students still rely on human relationships, role modeling, communication, and guidance. Teachers must be able to determine when to use AI and when decisions should remain entirely in human hands. These principles can be translated into school policies regarding data privacy, information verification, the use of AI in assessment, academic integrity, and student protection.

AI competency can be proportionately integrated into teacher performance management. Assessments should not be based on the sheer number of applications used, but rather on the quality and appropriateness of their application. Indicators may include the ability to select AI tools aligned with specific goals, verify outputs, integrate AI with pedagogy, ensure data security, apply ethical principles, engage in reflection, and participate in professional development. Thus, the focus of performance management shifts from mere technology use to responsible and effective technology use.

The strategic framework proposed in this article can be formulated into the following model:

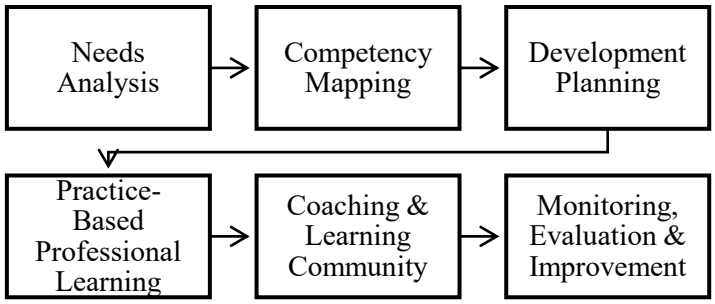


Figure 1. Strategic Framework for Teacher Competence Development in the AI Era

The framework is cyclical. The results of monitoring and evaluation serve as input for the subsequent needs analysis. Thus, teacher competency development management is positioned as a continuous process rather than a one-off training program.

Conclusion

The advancement of Artificial Intelligence has expanded the competency requirements for primary school teachers. The necessary competencies extend beyond mere technological proficiency to encompass AI knowledge, AI pedagogy, AI assessment, AI ethics, human-centered education, and professional engagement.

A literature review indicates that teacher competency development must be managed as part of a human resource management strategy. Schools need to shift from a one-off training approach toward a comprehensive competency development system that begins with needs analysis and competency mapping, followed by planning, practice-based professional learning, coaching, learning communities, and monitoring and evaluation. This article proposes a six-stage strategic framework for managing teacher competency development in the AI era. The framework positions the school principal as the manager of the competency development ecosystem, responsible for providing direction, support, policies, learning opportunities, and evaluation.

The study's key implication is that the success of AI transformation in primary schools hinges largely on the quality of human resource management. AI should be viewed as a tool that enhances teachers' professional capacity rather than a replacement for the human role. Further empirical research is required to validate the proposed framework through teacher AI competency mapping, instrument development, and the implementation of professional development models in primary schools.

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