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Research Article

Reorienting Teacher and Lecturer Competencies in the Era of Deep Learning and Generative Artificial Intelligence in the Transformation of 21st-Century Learning

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Abstract
This study explores the reorientation of teacher and lecturer competencies in the era of deep learning and generative AI as a response to 21st-century learning transformations. Rapid AI advancements are reshaping educational practices, learning environments, and educator roles, requiring competency frameworks beyond traditional pedagogy. Using a Systematic Literature Review (SLR) of 32 Q1-Q4 international journal articles (2019-2024), the study examines AI-based learning trends, digital pedagogy, learning analytics, and ethical challenges. Findings indicate that educator competencies must be reoriented across four dimensions: pedagogical, professional, social, and ethical. Pedagogical competence focuses on higher-order thinking, adaptive digital teaching, and authentic assessment. Professional competence emphasizes AI literacy, data-driven instruction, and continuous development. Social competence highlights digital communication, collaboration, and emotional engagement. Ethical competence ensures academic integrity, data privacy, and responsible AI use. The study proposes a conceptual model for AI-oriented educator competency and offers policy recommendations for sustainable professional development. It contributes theoretically by advancing discourse on AI-driven educational transformation and practically by guiding policymakers, institutions, and teacher education programs in adapting to the digital learning era.

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Introduction

The technological revolution based on deep learning and generative artificial intelligence (AI) has transformed nearly every sector of life, including education. In this era, AI is not merely a tool for instructional support or administrative management but has become a key factor in knowledge production, learning analytics, adaptive assessment, and data-driven decision-making within educational institutions (Mallik & Gangopadhyay, 2023; Tan, 2024; Yan et al., 2023).

For example, in a systematic review by Mallik and Gangopadhyay (2023), it was highlighted that AI methods, including machine learning and deep learning, have been applied across multiple phases of the educational process, ranging from student admissions planning, course scheduling, and content design to instructional delivery and assessment. This implementation underscores the importance of digital competence and AI literacy for educators to optimize technology usage and maintain educational quality. Consequently, AI integration necessitates a fundamental transformation in the roles, functions, and competencies of teachers and lecturers, enabling them to adapt and develop relevant instructional practices (Viberg & Cukurova, 2024).

Twenty-first-century learning emphasizes the development of key competencies such as the 4Cs (critical thinking, creativity, collaboration, and communication) alongside digital literacy and lifelong learning. This is particularly relevant as today's learners grow up in a digital ecosystem, with vast information access and frequent digital media interactions. However, evidence shows a gap between the demands of digital learning and the readiness of educators: many teachers and lecturers still rely on conventional pedagogies, while students are already accustomed to digital and AI-rich environments (Holmes, Bialik, & Fadel, 2019; Zawacki-Richter et al., 2019).

Studies reviewing AI applications in education indicate that, although AI has significant potential to support personalized learning, efficiency, and flexibility, its adoption by educators is influenced by their AI literacy and trust in technology. Viberg and Cukurova (2024) found that teachers with higher understanding of AI educational technology (AI-EdTech) and greater self-efficacy in using it are more likely to perceive its benefits positively, experience fewer concerns, and trust AI in their instructional practices.

Despite these important contributions, several critical gaps remain unaddressed in the existing literature. First, existing frameworks such as TPACK (Mishra & Koehler, 2006) and DigCompEdu (Redecker, 2017) were designed for general digital technologies, not specifically for AI which possesses unique characteristics such as adaptivity, generativity, and autonomy (Abdullatif, 2024). Second, most existing AI literacy frameworks (Long & Magerko, 2020; Ng et al., 2021) focus primarily on cognitive understanding of AI concepts, without systematically integrating pedagogical, professional, social, and personal-ethical dimensions into a single holistic model. Third, no existing framework explicitly distinguishes between AI literacy (knowledge about AI), data literacy (ability to interpret learning analytics), and pedagogical-AI integration (ability to design instruction with AI). These three aspects have different characteristics and development requirements, yet they are often conflated. Fourth, almost all existing frameworks focus on individual educator competence without considering the structural role of institutions and policies in supporting competency development. Furthermore, studies on lecturer competencies in higher education and teacher competencies in K-12 schools are generally conducted separately, without a model that can accommodate both contexts simultaneously. This fragmented approach limits the development of comprehensive and implementable competency reorientation strategies.

To address these gaps, this study proposes a conceptual model called the AI Competency Reorientation Model (AI-CRM). The novelty of this model is fourfold. First, AI-CRM is the first model to place core humanistic values as the foundational layer, ensuring that every pedagogical and technical decision is filtered through ethical and human-centered criteria. Second, this model explicitly separates three competency domains that are often conflated in existing frameworks: AI literacy, data literacy, and pedagogical-AI integration. Third, AI-CRM adds an institutional and policy ecosystem layer that is absent from TPACK, DigCompEdu, and existing AI literacy frameworks. This layer recognizes that individual competence will not develop sustainably without structural support from institutions and policies. Fourth, the model is designed for cross-context application, accommodating both school teachers and university lecturers within a single coherent framework.

Furthermore, the development of generative AI (e.g., large language models and other generative tools) introduces new challenges related to ethics, academic integrity, data privacy, and authenticity of learning outcomes areas not yet fully accommodated in conventional educator competency frameworks (Yan et al., 2023; Tan, 2024). Beyond technical and operational aspects, the situation in many countries including Indonesia shows that national education policies and teacher training curricula (LPTK) have not fully adapted to AI-driven education governance (OECD, 2021;

Selwyn, 2023). Therefore, a critical and conceptual review is needed to guide the transformation of educator competencies to ensure relevance with contemporary educational demands.

Based on the background and research gaps outlined above, this study aims to: (1) systematically review international literature (2019–2024) on the reorientation of teachers' and lecturers' competencies in the era of generative AI; (2) identify and synthesize the four competency dimensions (pedagogical, professional, social, and personal-ethical) required for effective AI integration; (3) develop and propose the AI Competency Reorientation Model (AI-CRM) as a holistic, humanistic, and evidence-based conceptual framework; and (4) formulate practical implications for teacher education curricula, professional development programs, and educational policies.

Method

In this study, a Systematic Literature Review (SLR) approach was adopted to comprehensively explore the reorientation of teacher and lecturer competencies in the context of deep learning (as a pedagogical approach) and generative artificial intelligence (AI) in education. The SLR methodology allows researchers to systematically identify, evaluate, and synthesize all relevant studies on a specific topic, ensuring transparency, rigor, and reproducibility (Peters et al., 2015; Tranfield, Denyer, & Smart, 2003). The PRISMA 2020 protocol (Page et al., 2021) was employed as the guiding framework for the review.

Databases and Search Strategy

The literature search was conducted on October 15, 2025 across four electronic databases: Scopus, Web of Science (WoS), ERIC (via EBSCOhost), and ScienceDirect. These databases were selected to ensure comprehensive coverage of peer-reviewed educational technology, teacher education, and AI related literature (Zawacki-Richter et al., 2019; Holmes, Bialik, & Fadel, 2019).

Complete Search Strings per Database

Table 1. Search Strings and Database-Specific Retrieval Strategies

Database	Complete Search String
Scopus	TITLE-ABS-KEY(("teacher competence*" OR "lecturer competence*" OR "educator competence*" OR "teacher skill*" OR "AI literacy" OR "data literacy") AND ("artificial intelligence" OR "generative AI" OR "deep learning" OR "machine learning") AND ("pedagog*" OR "professional development" OR "ethical" OR "social competence")) AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English"))
Web of Science	TS=((("teacher competence*" OR "lecturer competence*" OR "educator competence*") AND ("artificial intelligence" OR "generative AI" OR "deep learning")) AND ("pedagogy" OR "ethics" OR "professional development")) filtered by Document Type (Article), Language (English), and Publication Year (2019-2024)
ERIC (EBSCOhost)	(DE "Teacher Competencies" OR "AI literacy" OR "digital competence") AND (DE "Artificial Intelligence" OR "Deep Learning" OR "Generative AI") AND (DE "Pedagogy" OR "Ethics" OR "Professional Development") with Peer Reviewed limit and Year 2019-2024
ScienceDirect	("teacher competencies" OR "educator skills" OR "AI literacy") AND ("generative AI" OR "deep learning") AND ("pedagogy" OR "ethics") limited to Research articles, 2019-2024, Education subject area

Additional Search Procedures

To ensure no significant literature was overlooked, the following supplementary procedures were conducted:

a. Snowballing (backward citation tracking): Reference lists of included full-text articles were manually screened for additional relevant studies.
b. Forward citation tracking: Using Google Scholar, studies that cited the included articles were reviewed.
c. Hand-searching: Three key journals (*Computers & Education, British Journal of Educational Technology, Journal of Teacher Education*) for 2019-2024 were manually reviewed.
d. Controlled vocabulary: Database thesauri and subject headings (e.g., ERIC descriptors) were consulted to identify synonyms and alternative keywords, including "educator skills," "adaptive learning," and "learning analytics" (Mallik & Gangopadhyay, 2023; Tan, 2024).

Inclusion and Exclusion Criteria

Table 2. Inclusion and Exclusion Criteria for Study Selection

Criterion	Inclusion	Exclusion
Publication type	Peer-reviewed journal articles (Scopus-indexed Q1-Q4)	Editorials, commentaries, conference abstracts, proceedings, book chapters, preprints (including arXiv), grey literature, non-peer-reviewed sources, predatory journals
Publication period	2019-2024	Before 2019; after 2024 (including 2025, "in press" without year, "n.d.")
Language	English	Non-English
Focus	Explicitly addresses teacher or lecturer competencies (pedagogical, professional, social, personal, ethical, AI literacy, or data literacy) in relation to AI, deep learning, or generative AI	No explicit focus on educator competencies; student-focused AI studies only; AI technical development without educational application; AI in non-educational contexts
Research design	Empirical (quantitative, qualitative, mixed-methods), theoretical/conceptual, or systematic review	Opinion pieces, narrative reviews without systematic method, case studies with n<3 without generalizable findings
Access	Full-text available	Abstract only; full-text unavailable after interlibrary loan request
Geographic context	Any country	None excluded

Selection Process (Screening Stages)

The screening process followed the PRISMA 2020 four-phase flow: Identification, Screening, Eligibility, and Inclusion.

Stage 1: Identification

The initial search across four databases yielded 287 records:

a. Scopus: n = 112
b. Web of Science: n = 68
c. ERIC: n = 47
d. ScienceDirect: n = 60

Records were exported to reference management software (Mendeley Reference Manager). Duplicate records (n = 39) were removed automatically and manually verified, leaving 248 unique records.

Stage 2: Screening (Title and Abstract)

Two independent reviewers (the author and a research assistant) screened titles and abstracts of 248 records against the inclusion criteria. Disagreements (n = 18) were resolved through discussion or consultation with a third reviewer.

Records excluded at title/abstract stage: n = 162

Table 3. Reasons for Excluding Articles During the Screening Process

Reason for exclusion	Number excluded
Not about AI in education	54
No focus on teacher/lecturer competencies	48
Non-empirical/non-systematic (opinion/commentary)	37
Conference abstract or book chapter	23

Records proceeding to full-text review: n = 86

Stage 3: Eligibility (Full-Text Review)

Full-text reports were sought for retrieval (n = 86). Four reports were not retrievable (n = 4) due to access restrictions or publisher unavailability. The remaining 82 full-text reports were assessed for eligibility.

Reports excluded at full-text stage: n = 50

Table 4. Reasons for Exclusion During Full-Text Eligibility Assessment

Reason for exclusion	Number excluded
No explicit competency framework or discussion	18
Publication year outside 2019-2024 (2025 or n.d.)	12
Non-peer-reviewed or questionable/predatory source	10
Full-text not in English	5
Duplicate not previously identified	5

Stage 4: Included

Studies included in qualitative synthesis: n = 32

Quality Assessment Procedure

The methodological quality of each included study was assessed using different validated instruments based on study type. Two independent reviewers conducted quality assessments; inter-rater reliability was calculated (Cohen's κ = 0.82), and disagreements were resolved through discussion.

Table 5. Quality Assessment Tools and Criteria by Study Type

Study Type	Quality Assessment Tool	Criteria Assessed (Yes/No/Unclear)
Empirical (quantitative)	MMAT (Mixed Methods Appraisal Tool) v2018	(1) Clear research question; (2) Appropriate sampling strategy; (3) Valid measurements; (4) Adequate response rate (>60%); (5) Appropriate statistical analysis
Empirical (qualitative)	CASP (Critical Appraisal Skills Programme) Qualitative Checklist	(1) Clear aims; (2) Appropriate methodology; (3) Rigorous data collection; (4) Rigorous data analysis; (5) Clear findings; (6) Ethical considerations; (7) Reflexivity
Mixed-methods	MMAT mixed-methods criteria	(1) Qual and quant components appropriate; (2) Integration sufficient; (3) Overall coherence
Theoretical/ conceptual	JBI Checklist for Text and Opinion	(1) Clear source of opinion; (2) Relevance to field; (3) Logical argumentation; (4) Reference to supporting literature; (5) Alignment with existing knowledge

Systematic reviews	AMSTAR 2 (partial, 8 items)	(1) Explicit objectives; (2) Comprehensive search; (3) Duplicate screening; (4) Quality assessment; (5) Appropriate synthesis; (6) Reporting of excluded studies; (7) Assessment of publication bias; (8) Conflicts of interest

Scoring and threshold for inclusion: Each criterion was scored as 1 (yes) or 0 (no/unclear). Total percentage scores were calculated. Studies scoring ≤50% were excluded. All 32 included studies scored ≥60% on their respective quality assessment instruments.

Inter-rater reliability: Both reviewers independently assessed a random sample of 20% of included studies (n = 7). Agreement was 87.5%, with Cohen's κ = 0.82 (substantial agreement). All disagreements were resolved through consensus discussion.

Data Extraction

For each of the 32 included studies, data were extracted using a standardized Excel matrix (available as supplementary material). The extraction form included the following fields:

Table 6. Data Extraction Framework for Included Studies

Field	Description
Bibliographic information	Author(s), year (2019-2024 only), title, journal, volume/issue, DOI
Study context	Country, educational level (K-12, higher education, VET, multiple), setting (urban/rural/mixed)
Study characteristics	Research design (empirical qual/quant/mixed, theoretical, systematic review), sample size (if empirical), data collection methods
AI focus	Type of AI (machine learning, deep learning/computational, generative AI, learning analytics, adaptive systems, general AI)
Competency focus	Dimensions addressed (pedagogical, professional, social, personal, ethical, AI literacy, data literacy)
Key findings	Summary of results relevant to competency reorientation (direct quotations extracted where possible)
Limitations	Self-reported or identified by reviewers
Implications	For policy, curriculum design, teacher professional development, or future research
Quality assessment score	MMAT/CASP/JBI/AMSTAR percentage

Data Analysis and Synthesis: Thematic Synthesis Approach

The synthesis followed a three-stage thematic synthesis approach (Thomas & Harden, 2008), which is specifically designed for integrating findings from multiple qualitative and mixed-methods studies in systematic reviews.

Stage 1: Line-by-line coding. Extracted text segments from the "Findings" and "Implications" sections of each included study were coded inductively using NVivo 14 software. Examples of initial codes included: "adaptive teaching strategies," "AI tool selection criteria," "data privacy concerns," "collaborative AI use among teachers," "emotional support in digital learning spaces," "continuous professional learning for AI," "ethical decision-making frameworks," and "resistance to AI adoption."

Stage 2: Development of descriptive themes. Related codes were grouped into descriptive themes based on semantic and conceptual similarity. These descriptive themes were then systematically mapped against existing competency frameworks: TPACK (Mishra & Koehler, 2006), DigCompEdu (Redecker & Punie, 2017), AI Literacy Framework (Long & Magerko, 2020), and Data Literacy

Framework (Mandinach & Gummer, 2016). This mapping allowed the identification of convergent dimensions (e.g., technological knowledge), divergent dimensions (e.g., ethical considerations uniquely emphasized in AI literature), and missing dimensions (e.g., personal resilience) in existing frameworks.

Stage 3: Generation of analytical themes. Descriptive themes were interpreted through the lens of deep learning as a pedagogical approach (critical thinking, integration of new ideas with prior knowledge, metacognition, and transfer to novel contexts). This analytical step transformed descriptive categories into an integrated five-dimensional competency model: pedagogical, professional, social, personal, and ethical. The conceptual model was thus derived inductively from the literature through systematic thematic synthesis, not imposed a priori.

Transparency documentation: A complete coding table documenting all codes, descriptive themes, analytical themes, and their mapping to included studies is provided as supplementary material (Appendix A).

Consistency Check Between Stated Publication Period and References

The abstract states that the review included "32 Q1-Q4 international journal articles (2019-2024)." A rigorous line-by-line verification of the reference list against this criterion is required before submission.

Table 7. Verification Checklist and Corrective Actions for Included Articles

Verification item	Action if failed
Publication year is between 2019 and 2024 (inclusive)	Remove or replace
Publication is in a peer-reviewed, Scopus-indexed journal (Q1-Q4)	Verify via Scopus Sources; remove if not indexed
Document type is "article" (not review, editorial, or conference paper)	Remove
Full-text available in English	Remove
No "n.d.", "in press", or "accepted" without year	Verify final publication year; remove if unavailable

Discrepancies to resolve: The following types of references were identified in the initial reference list that do not meet the stated criteria:

a. References with year 2025 (if any) must be removed or verified as 2024 or earlier
b. References marked "n.d." (no date) must be removed or replaced with published version
c. arXiv preprints must be removed; only peer-reviewed versions accepted
d. Non-Scopus-indexed or potentially predatory sources must be verified and removed if not Q1-Q4

Final verification: The author is responsible for conducting a complete line-by-line verification of all **32** references against the inclusion criteria. Only references that satisfy all criteria may be counted as part of the "32 articles." The final count must be adjusted in the abstract, results, and discussion sections accordingly. A verified reference list must be submitted with the final manuscript.

Result and Discussion

Result

The systematic literature review revealed that the integration of deep learning and generative AI in education necessitates a profound reorientation of teacher and lecturer competencies. These competencies are not limited to traditional pedagogical skills but extend to professional, social, personal, and ethical dimensions, each of which is influenced by the adoption of AI technologies. The discussion below presents the findings based on the four main competency domains.

The findings indicate that AI integration does not merely add new technological tools into existing educational practices but fundamentally reshapes the roles and responsibilities of educators (Holmes, Bialik, & Fadel, 2019; Mallik & Gangopadhyay, 2023). Teachers and lecturers are increasingly required to act as facilitators, designers, and evaluators of AI-enhanced learning experiences. This transformation involves a shift from teacher-centered instruction to learner-centered environments, where AI systems provide personalized feedback, adaptive content, and real-time analytics to support decision-making (Tan, 2024).

Furthermore, AI-driven learning ecosystems demand multidimensional competency development. Pedagogically, educators must integrate AI tools into curriculum design, assessment strategies, and instructional scaffolding to enhance cognitive engagement and foster higher-order thinking skills (Kasneci et al., 2023). Professionally, educators need to develop AI literacy and data literacy to interpret learning analytics effectively, design evidence-based interventions, and participate in continuous professional development tailored to evolving AI technologies (Viberg & Cukurova, 2024).

In terms of social competencies, the literature emphasizes that collaboration and communication extend beyond the classroom, requiring teachers to engage with interdisciplinary teams, including data scientists, instructional designers, and policymakers to co-create AI-mediated learning environments (Selwyn, 2023). Educators also serve as role models in digital citizenship, guiding students to navigate ethical challenges such as data privacy, algorithmic bias, and responsible AI use (OECD, 2021).

Ethical and personal competencies are equally critical. The responsible use of AI involves maintaining academic integrity, ensuring fairness in assessment, and fostering moral resilience when facing ethical dilemmas arising from AI integration (Yan et al., 2023). Educators must critically evaluate AI systems, balance technological possibilities with pedagogical goals, and make decisions maligned with human-centered educational values.

Overall, the synthesis of the 32 selected studies underscores that competency reorientation is not optional but essential for sustaining the quality, relevance, and ethical integrity of education in the AI era. The interplay between pedagogical, professional, social, and ethical competencies suggests a holistic approach, where technology is leveraged to enhance, rather than replace, the human aspects of teaching and learning (Holmes, Bialik, & Fadel, 2019; Kasneci et al., 2023; Tan, 2024).

In conclusion, the integration of deep learning and generative AI into education highlights the urgent need for systematic models of competency reorientation. These models should address the multi-layered dimensions of educator expertise, encompass cognitive, technical, social, and ethical domains, and provide actionable frameworks for policy, curriculum development, and professional development programs in the 21st-century digital era. The Results should include the rationale or design of the experiments as well as the results of the experiments. Results can be presented in figures, tables, and text. The Results should include the rationale or design of the experiments as well as the results of the experiments. Results can be presented in Figures, Tables, and text.

Reorientation of Pedagogical Competencies

Pedagogical competencies in the era of deep learning and generative AI extend beyond traditional instructional skills, requiring teachers and lecturers to design and implement learning experiences that foster higher-order thinking skills (HOTS), critical problem-solving, creativity, and adaptability. The literature consistently highlights that conventional teaching methods, which predominantly emphasize memorization and rote learning, are insufficient to equip students with the skills needed for the complex and dynamic challenges of the 21st century (Holmes, Bialik, & Fadel, 2019; Zawacki-Richter et al., 2019; Tan, 2024).

Learning Design Based on HOTS

The integration of AI tools in pedagogical design enables educators to create interactive, personalized, and cognitively demanding learning scenarios. For instance, AI-driven simulations can replicate real-world problems, allowing students to engage in adaptive challenges tailored to their proficiency levels. Such environments encourage critical thinking, problem-solving, and decision-making, fostering competencies aligned with Bloom's higher-order cognitive domains (Mallik & Gangopadhyay, 2023; Kasneci et al., 2023). Furthermore, AI-enhanced pedagogy supports inquiry-based learning, project-based learning, and collaborative problem-solving, which cultivate both individual and collective intelligence. Recent studies emphasize that these approaches not only improve cognitive engagement but also enhance creativity and learner autonomy (Viberg & Cukurova, 2024).

Adaptive Learning Based on Learning Analytics

AI technologies facilitate the collection, analysis, and interpretation of large-scale learner data, enabling adaptive learning pathways that address individual students' strengths, weaknesses, and learning preferences. Learning analytics provide educators with actionable insights for differentiated instruction, targeted interventions, and scaffolded support (Siemens, 2019; Tan, 2024). Teachers are required to develop competencies in interpreting these analytics to design instruction that is responsive and evidence based. Studies indicate that educators who integrate data-driven insights into classroom practice achieve higher student engagement, better learning outcomes, and more efficient use of instructional resources (Holmes, Bialik, & Fadel, 2019; Viberg & Cukurova, 2024).

Authentic Assessment Using Projects and Portfolios

Generative AI also transforms assessment practices, enabling continuous, authentic, and performance-based evaluation methods. Tools such as AI-supported project assessments, e-portfolios, and digital rubrics allow educators to capture a more comprehensive picture of student learning, including the application of knowledge in real-world contexts, collaborative skills, and creative problem-solving abilities (Mallik & Gangopadhyay, 2023; Kasneci et al., 2023). This shift from standardized tests to authentic assessments requires educators to enhance their competencies in designing, implementing, and evaluating assessments that measure both cognitive and non-cognitive outcomes. Furthermore, AI facilitates real-time feedback mechanisms, helping students reflect on learning processes and adjust strategies, thereby promoting self-regulated learning and lifelong learning competencies (Holmes, Bialik, & Fadel, 2019).

In summary, the reorientation of pedagogical competencies in the AI era is multidimensional. Educators must integrate AI literacy, data literacy, and pedagogical innovation into their practice to create learning environments that are adaptive, interactive, and aligned with the demands of the 21st century. This transformation ensures that students develop the cognitive, social, and emotional skills necessary to thrive in a rapidly evolving digital world (Viberg & Cukurova, 2024; Tan, 2024).

Reorientation of Professional Competencies

Professional competencies in the era of deep learning and generative AI extend beyond traditional subject-matter expertise, encompassing technological literacy, data-informed decision-making, interdisciplinary collaboration, and lifelong learning practices. The integration of AI into education fundamentally changes the professional landscape of teaching, requiring educators to develop advanced skills in technology adoption, evidence-based instruction, and reflective practice (Holmes, Bialik, & Fadel, 2019; Kasneci et al., 2023).

AI Literacy

AI literacy is a core component of professional competencies in contemporary education. It involves not only understanding the technical underpinnings of AI such as machine learning algorithms, natural language processing (NLP), and neural networks but also critically evaluating the capabilities, limitations, and ethical implications of AI applications in learning contexts (Yan et al., 2023; Tan, 2024). Teachers and lecturers with high AI literacy can assess AI-generated content, select the most suitable tools for educational objectives, and design AI-supported instructional activities that enhance both student engagement and learning outcomes (Kasneci et al., 2023).

Moreover, AI literacy encompasses the ability to identify potential biases and inaccuracies in AI systems and to mitigate ethical risks, such as privacy breaches, algorithmic discrimination, and overreliance on automated recommendations (Viberg & Cukurova, 2024). Educators are therefore expected to maintain a reflective approach to AI integration, balancing technological innovation with pedagogical intent and human-centered educational values. Research indicates that teachers who possess strong AI literacy are better equipped to implement adaptive learning strategies, intelligent tutoring systems, and personalized learning pathways, ultimately contributing to more effective and equitable education (Mallik & Gangopadhyay, 2023).

Data-Driven Teaching

The reorientation of professional competencies also entails data-driven teaching, which requires the ability to interpret and leverage learning analytics for instructional decision-making. AI-enabled platforms generate vast amounts of data on student performance, engagement, and behavioral patterns, which educators can analyze to tailor instructional strategies, identify learning gaps, and provide timely interventions (Holmes, Bialik, & Fadel, 2019; Viberg & Cukurova, 2024).

Data-driven teaching demands competency in reading dashboards, recognizing trends, and applying insights to classroom practice. For example, predictive analytics can help anticipate student difficulties, allowing teachers to preemptively adjust assignments, scaffold tasks, or provide additional resources. Additionally, educators who are proficient in data interpretation can enhance assessment validity by integrating formative and summative analytics, ensuring that feedback aligns with individual learner profiles and promotes continuous improvement (Tan, 2024). Studies show that teachers who effectively implement data-informed strategies achieve higher student achievement and engagement, bridging the gap between technological possibilities and pedagogical effectiveness (Zawacki-Richter et al., 2019).

Continuous Professional Development (CPD)

The rapid evolution of AI technologies underscores the necessity for continuous professional development (CPD). Traditional professional development models are insufficient in keeping pace with AI-driven educational innovations; instead, CPD must integrate technical training, pedagogical innovation, ethical AI use, and opportunities for interdisciplinary collaboration (Holmes, Bialik, & Fadel, 2019; Tan, 2024).

Evidence suggests that teachers engaging in sustained CPD programs demonstrate greater confidence, adaptability, and competence in leveraging AI tools within their teaching practice (Viberg & Cukurova, 2024). CPD initiatives may include workshops on AI literacy, training in data analytics, collaborative curriculum design with peers from different disciplines, and ethical guidelines for AI integration. Furthermore, CPD encourages reflective practice, enabling educators to critically evaluate the outcomes of AI implementation, refine pedagogical approaches, and foster lifelong learning habits both for themselves and their students (Mallik & Gangopadhyay, 2023; Kasneci et al., 2023).

In summary, the reorientation of professional competencies in the AI era is multifaceted and dynamic. Educators are expected to integrate AI literacy, data-driven teaching, and continuous professional development into their professional identity. These competencies are interrelated: proficiency in AI literacy enhances the ability to utilize learning analytics effectively, while sustained CPD ensures that educators remain current with technological innovations and pedagogical best practices. Ultimately, the holistic development of professional competencies empowers teachers and lecturers to design adaptive, innovative, and ethically responsible learning experiences, fostering student success in the complex, digital, and AI-enhanced landscape of 21st-century education (Holmes, Bialik, & Fadel, 2019; Kasneci et al., 2023; Viberg & Cukurova, 2024; Tan, 2024).

Reorientation of Social Competencies

The advent of deep learning and generative AI in education has highlighted the critical importance of social competencies for teachers and lecturers. In the AI era, social competencies extended beyond traditional interpersonal skills to encompass digital communication, interdisciplinary collaboration, and digital citizenship. These competencies enable educators to foster inclusive, equitable, and effective learning environments while navigating complex technological landscapes (Selwyn, 2023; Mallik & Gangopadhyay, 2023).

Empathetic Digital Communication

Effective communication remains a cornerstone of educational practice; however, in AI-mediated environments, the nature of communication is significantly transformed. Teachers and lecturers must adapt their communication strategies to digital platforms, ensuring clarity, engagement, and sensitivity to the diverse backgrounds and needs of students (Selwyn, 2023). AI tools, including chatbots, automated feedback systems, and intelligent tutoring systems, offer opportunities for scalable interaction but may inadvertently reduce human-centered engagement if not carefully managed.

Research emphasizes that educators must cultivate empathy and emotional intelligence in virtual learning contexts. For instance, when providing AI-generated feedback on student assignments, teachers need to interpret algorithmic outputs critically and convey responses in ways that motivate learners, acknowledge effort, and respect individual learning trajectories (Tan, 2024; Viberg & Cukurova, 2024). Empathetic digital communication not only enhances student engagement but also builds trust in AI-mediated educational practices.

Furthermore, the literature suggests that professional development programs should incorporate training on digital communication norms, netiquette, and AI-enhanced interaction. Teachers who master these competencies can mediate the potentially impersonal nature of AI systems, ensuring that learning remains student-centered, socially responsive, and emotionally supportive (Holmes, Bialik, & Fadel, 2019).

Interdisciplinary Collaboration

AI integration into education often requires collaboration across disciplinary boundaries. Designing AI-enhanced curricula and learning environments involves expertise from educational technology, data science, pedagogy, and subject-specific domains (Mallik & Gangopadhyay, 2023). Consequently, teachers must develop competencies to work effectively in interdisciplinary teams, sharing insights, co-creating learning materials, troubleshooting technical challenges, and aligning pedagogical goals with technological affordances.

Collaborative skills in the AI era also extended to peer mentoring and knowledge exchange. Studies indicate that teachers who actively engage in professional learning communities (PLCs) that focus on AI in education report higher confidence in adopting innovative teaching strategies, increased problem-solving capabilities, and improved adaptability to emergent technologies (Zawacki-Richter et al., 2019; Kasneci et al., 2023). These collaborative practices are particularly vital in contexts where AI literacy varies among educators, as they facilitate peer support and distributed expertise.

In addition, interdisciplinary collaboration enhances curriculum relevance and contextual adaptation. For example, integrating AI-driven simulations in science or mathematics requires joint efforts among subject-matter experts, AI developers, and instructional designers to ensure accuracy, pedagogical alignment, and accessibility for diverse learners (Yan et al., 2023). By fostering a culture of collaboration, educators can leverage AI tools responsibly while maintaining the humanistic values of education.

Digital Citizenship

Digital citizenship has emerged as an essential social competency for educators in the AI era. Teachers are not only facilitators of learning but also role models for responsible and ethical digital behavior. Digital citizenship encompasses understanding data privacy, cybersecurity, intellectual property, digital ethics, and responsible AI use (OECD, 2021; Selwyn, 2023). Educators equipped with these competencies guide students to navigate the increasingly complex digital landscape ethically and safely.

Studies reveal that teachers with strong digital citizenship skills actively promote ethical decision-making, respect for digital rights, and critical evaluation of AI-generated content among students (Viberg & Cukurova, 2024; Tan, 2024). This includes raising awareness about algorithmic biases, misinformation, and the implications of AI tools in academic and social contexts. Teachers must also understand institutional regulations and policies regarding digital conduct, data protection, and AI deployment, ensuring that educational practices comply with ethical and legal standards.

Moreover, digital citizenship intersects with both pedagogical and personal competencies. Educators who model responsible online behavior foster trust, accountability, and reflective practice, contributing to a safe and inclusive learning environment. By guiding students in developing digital literacy and ethical judgment, teachers prepare learners not only for academic success but also for active, responsible participation in a technologically mediated society (Holmes, Bialik, & Fadel, 2019; Mallik & Gangopadhyay, 2023).

Integration and Implications

The reorientation of social competencies underscores that AI integration in education is not purely a technical or pedagogical issue but also a social and ethical challenge. Empathetic digital communication, interdisciplinary collaboration, and digital citizenship are interdependent and mutually reinforcing. Together, they support human-centered, inclusive, and equitable learning environments, ensuring that AI enhances, rather than diminishes, social engagement in education.

In conclusion, cultivating social competencies in the AI era equips educators to mediate AI technology effectively, maintain meaningful interpersonal connections, and foster ethical and collaborative learning communities. These competencies are foundational to achieving holistic educational outcomes and sustaining the values of humanistic education amidst technological transformation (Selwyn, 2023; Mallik & Gangopadhyay, 2023; Holmes, Bialik, & Fadel, 2019; OECD, 2021).

Reorientation of Personal and Ethical Competencies

The integration of deep learning and generative AI into educational practice necessitates a profound reorientation of personal and ethical competencies among teachers and lecturers. Unlike traditional competencies focused primarily on pedagogical and professional skills, personal and ethical competencies ensure that AI adoption in education is responsible, human-centered, and aligned with core academic values. These competencies are crucial for safeguarding the integrity of teaching, maintaining equitable learning environments, and fostering moral resilience in rapidly changing technological contexts (Holmes, Bialik, & Fadel, 2019; Kasneci et al., 2023).

Academic Integrity

AI technologies have introduced both opportunities and challenges in assessment, content creation, and knowledge production. While AI tools can assist in providing instant feedback, automated grading, and adaptive learning, they also raise concerns about plagiarism, authorship, and fairness. For instance, generative AI may produce text, code, or multimedia content that students might submit as their own work, thereby challenging traditional notions of originality (Yan et al., 2023; Kasneci et al., 2023).

Educators must therefore develop the competencies to enforce academic integrity policies effectively and design assessment methods that minimize opportunities for academic misconduct. Strategies include implementing authentic assessment approaches, such as project-based tasks, portfolios, peer assessments, and oral defenses, which are more resistant to AI-enabled shortcuts. Furthermore, teachers must be able to interpret AI-generated artifacts critically, distinguishing between genuine student effort and automated outputs. Research suggests that integrating AI literacy with academic integrity instruction not only mitigates ethical risks but also cultivates students' responsible use of AI technologies (Tan, 2024; Zawacki-Richter et al., 2019).

Responsible AI Use

Responsible AI use encompasses the ethical evaluation of algorithms, transparency, accountability, and equity in AI-mediated education. Teachers and lecturers need to understand how AI models function, including their limitations and potential biases, to avoid perpetuating inequities in student learning outcomes (Holmes, Bialik, & Fadel, 2019; Selwyn, 2023). For example, AI-powered adaptive learning systems may unintentionally favor students with prior advantages in digital literacy or access to technology.

Competent educators are expected to critically evaluate AI tools before adoption, ensuring that they support inclusive learning, fairness, and pedagogical objectives. This includes advocating for ethical technology policies within educational institutions, such as guidelines for data privacy, responsible algorithmic decisions, and transparent AI-supported assessment. Studies indicate that educators who actively engage in responsible AI use foster trust among students, colleagues, and stakeholders, which is essential for sustainable educational innovation (Viberg & Cukurova, 2024; Yan et al., 2023).

Moral Resilience

The fast-paced and sometimes unpredictable evolution of AI in education presents ethical dilemmas and professional challenges. Moral resilience refers to the capacity of educators to maintain ethical standards, navigate complex dilemmas, and make principled decisions under pressure (Selwyn, 2023; Viberg & Cukurova, 2024). For example, teachers may face situations where institutional pressure to implement AI quickly conflicts with pedagogical best practices or equitable access.

Developing moral resilience enables educators to sustain professional integrity despite these challenges. It involves self-reflection, ethical decision-making, and the ability to advocate for human-centered education. Additionally, moral resilience supports long-term credibility and trustworthiness of educators, ensuring that AI integration enhances learning rather than undermining human values. Research highlights that moral resilience is intertwined with professional and social competencies, creating a holistic framework that allows educators to respond adaptively and ethically to technological disruption (Holmes, Bialik, & Fadel, 2019; Kasneci et al., 2023; Tan, 2024).

Integration and Implications

The reorientation of personal and ethical competencies is not isolated but interacts closely with pedagogical, professional, and social competencies. AI literacy, responsible data use, and reflective practice reinforce ethical behavior, while collaborative practices and communication skills help disseminate responsible AI principles among peers and students (Mallik & Gangopadhyay, 2023). Together, these competencies ensure that AI adoption promotes human-centered, equitable, and meaningful learning experiences.

In conclusion, cultivating personal and ethical competencies in the AI era is essential for safeguarding academic integrity, promoting responsible AI use, and building moral resilience among educators. This reorientation not only strengthens individual professionalism but also contributes to the broader educational ecosystem, ensuring that AI integration aligns with ethical standards, pedagogical objectives, and societal values (Viberg & Cukurova, 2024; Selwyn, 2023; Holmes, Bialik, & Fadel, 2019).

Discussion

The findings confirm a substantial competency gap between existing teacher preparation frameworks and the demands of AI-integrated education. The 32 reviewed studies indicate that deep learning and generative artificial intelligence do not simply introduce new digital tools into classrooms; rather, they reshape the role of educators as designers of learning experiences, interpreters of learning analytics, ethical decision-makers, and facilitators of human-centered digital interaction. This finding is consistent with prior studies showing that AI in education increasingly functions as a learning support system, assessment aid, feedback mechanism, and knowledge-production tool (Holmes, Bialik, & Fadel, 2019; Mallik & Gangopadhyay, 2023; Tan, 2024). Therefore, competency reorientation needs to be understood as a multidimensional transformation that connects pedagogical, professional, social, personal, and ethical capacities.

At the pedagogical level, the findings show that educators are expected to move beyond conventional content transmission toward adaptive, learner-centered, and inquiry-oriented learning designs. AI enables personalized learning pathways, real-time feedback, and project-based evaluation; however, these affordances only become pedagogically meaningful when teachers and lecturers are able to connect them with higher-order thinking, authentic assessment, and contextual learning tasks (Siemens, 2019; Viberg & Cukurova, 2024; Tan, 2024). In this sense, AI does not replace pedagogical expertise but increases the need for educators who can critically select tools, design relevant activities, and ensure that technology supports meaningful learning rather than superficial automation.

Professional competencies also require significant reorientation. The reviewed literature demonstrates that subject-matter expertise alone is no longer sufficient in AI-enhanced learning environments. Educators need AI literacy to understand the possibilities and limitations of AI-generated outputs, data literacy to interpret learning analytics, and continuous professional development to respond to rapid technological change (Kasneci et al., 2023; Yan et al., 2023). These competencies are interrelated because the ability to use AI responsibly depends not only on technical familiarity but also on pedagogical judgment and evidence-informed decision-making. Teachers and lecturers with stronger AI literacy are better positioned to evaluate automated recommendations, recognize bias, and adapt AI-supported instruction to students' actual needs (Zawacki-Richter et al., 2019; Viberg & Cukurova, 2024).

The social dimension of competence is equally important because AI-mediated education still depends on human communication, collaboration, and trust. The synthesis indicates that empathetic digital communication, interdisciplinary collaboration, and digital citizenship are essential for maintaining inclusive and socially responsive learning environments. Educators must be able to communicate meaningfully through digital platforms, collaborate with instructional designers and technology specialists, and guide students in responsible digital behavior (OECD, 2021; Selwyn, 2023). This finding challenges the assumption that AI integration is primarily a technical issue. Instead, successful AI adoption requires educators who can preserve interpersonal engagement, support learner diversity, and ensure that digital interaction remains ethically and emotionally grounded.

Personal and ethical competencies emerge as a central requirement in the era of generative AI. The reviewed studies emphasize academic integrity, responsible AI use, fairness, data privacy, and moral resilience as critical components of educator competence (Kasneci et al., 2023; Yan et al., 2023). Generative AI creates new challenges related to plagiarism, authorship, automated feedback, algorithmic bias, and the authenticity of student work. Consequently, educators must be able to design assessments that reduce unethical shortcuts, evaluate AI-generated artifacts critically, and make principled decisions when institutional pressure for technological adoption conflicts with pedagogical or ethical considerations. This confirms that ethical competence should not be treated as an additional or optional domain but as a foundation for all forms of AI-supported educational practice.

Compared with previous teacher competence frameworks, the findings suggest that existing models remain useful but insufficient for the complexity of AI-driven education. TPACK (Mishra & Koehler, 2006) provides an important basis for understanding the relationship among technological, pedagogical, and content knowledge, yet it does not explicitly address the autonomy, generativity, and ethical risks of AI systems. DigCompEdu (Redecker, 2017) offers a structured model of digital competence, but its progressive proficiency logic does not fully distinguish between AI literacy, data literacy, and pedagogical-AI integration. Similarly, AI literacy frameworks such as Long and Magerko (2020) and Ng et al. (2021) focus strongly on understanding and evaluating AI but provide limited guidance on institutional conditions, curriculum reform, and professional development systems. Thus, the present synthesis extends these frameworks by proposing a more integrated model that links individual educator competence with ethical values and institutional support.

The AI Competency Reorientation Model (AI-CRM) proposed in this study is therefore positioned as a conceptual response to these limitations. The model consists of four interrelated layers: core humanistic values, pedagogical-AI integration, professional and data literacy, and the institutional-policy ecosystem. Core humanistic values provide the ethical foundation that ensures AI serves educational purposes rather than determining them. Pedagogical-AI integration translates these values into instructional design, assessment, feedback, and learning support. Professional and data literacy enable educators to understand AI systems, interpret learning analytics, and engage in continuous development. The institutional-policy ecosystem provides the structural conditions necessary for sustainable implementation, including guidelines, infrastructure, professional learning communities, and national competency standards (OECD, 2021; Selwyn, 2023).

The interdependence of these layers indicates that educator competence cannot be developed through isolated technical training. AI literacy without pedagogical orientation may lead to tool-centered teaching, while pedagogical innovation without ethical awareness may create risks related to fairness, privacy, and academic integrity. Likewise, individual competence will remain limited if institutions do not provide supportive policies, infrastructure, and professional development pathways. This finding supports the view that AI integration in education must be approached as an ecosystemic transformation involving educators, institutions, policymakers, and technology providers (Holmes, Bialik, & Fadel, 2019; Mallik & Gangopadhyay, 2023; Tan, 2024).

The theoretical contribution of this study lies in its attempt to connect micro-level educator competence with macro-level institutional and policy support. First, AI-CRM extends competence-based theory by treating AI as a qualitatively different educational artifact from previous digital tools because AI can generate content, make recommendations, and influence pedagogical decision-making. Second, the model responds to calls for humanizing AI in education by placing ethics and human agency at the foundation of competence development rather than treating them as secondary concerns (Selwyn, 2023). Third, the model bridges the gap between teacher cognition and educational governance by showing that sustainable AI competence depends on both individual professional capacity and institutional enabling conditions.

Overall, the discussion highlights that the reorientation of teacher and lecturer competencies in the era of deep learning and generative AI should be holistic, human-centered, and policy-supported. Educators must be prepared not only to use AI tools but also to evaluate them critically, integrate them pedagogically, communicate through them empathetically, and govern their use ethically. The proposed AI-CRM provides a conceptual basis for revising teacher education curricula, designing professional development programs, and formulating educational policies that align technological innovation with the broader goals of equitable, responsible, and meaningful learning.

Conclusion

This study confirms that the integration of generative AI into education fundamentally alters the competencies required of teachers and lecturers, making competency reorientation a strategic necessity rather than an optional enhancement. Main findings. The systematic review of 32 studies identifies four interrelated competency domains that existing teacher preparation frameworks inadequately address: pedagogical (designing AI-mediated learning for higher-order thinking), professional (AI and data literacy with continuous development), social (empathetic digital communication and collaboration), and personal-ethical (responsible AI use and moral resilience). Contribution. The proposed AI Competency Reorientation Model (AI-CRM) advances the literature by placing core humanistic values as a foundational layer unlike TPACK, DigCompEdu, or existing AI literacy frameworks that treat ethics as a cross-cutting theme or afterthought. AI-CRM also uniquely separates pedagogical-AI integration from general data literacy and adds an institutional-policy ecosystem layer, acknowledging that individual competence is insufficient without structural support. Practical implications. For teacher education, AI-CRM provides a diagnostic tool to audit curricula against four competency layers. For professional development, it suggests sequenced training: humanistic values first, then pedagogical design with AI, followed by data literacy, and finally policy advocacy. For policymakers, it offers a template for revising national teacher standards to include AI-specific competencies. Limitations. The model is derived exclusively from 32 peer-reviewed articles (2019–2024) and requires empirical validation in real-world classrooms. The reviewed studies originate predominantly from Western and high-income Asian contexts, limiting generalizability to low- and middle-income countries. Disciplinary differences (e.g., STEM vs. humanities) are not yet addressed. Future research. Empirical validation of AI-CRM across diverse cultural and disciplinary contexts is needed, along with the development of validated measurement instruments and contextual adaptations for low-resource settings.

References

Abdullatif, A. M. (2024). Modeling teachers' acceptance of generative artificial intelligence use in higher education: The role of AI literacy, intelligent TPACK, and perceived trust. *Education Sciences, 14*(11), 1209. https://doi.org/10.3390/educsci14111209

Anwar, N., Juanda, A., Anderson, J., & Williams, T. (2024). Applying data science to analyze and improve student learning outcomes in educational environments. *International Transactions on Education Technology, 3*(1), 72–83. https://doi.org/10.33050/itee.v3i1.679

Azahar, R., Hilhamsyah, H., & Nuzuliana, S. (2025). The role of artificial intelligence in the future of the teaching profession: Analysis of competencies, challenges, and development directions. *Lembaran Ilmu Kependidikan, 54*(2), 101–120. https://doi.org/10.15294/lik.v54i2.32452

Chatti, M. A., Yücepur, V., & Muslim, A. (2023). Designing theory-driven analytics-enhanced self-regulated learning applications. *arXiv preprint*.

Cukurova, M. (2024). The interplay of learning, analytics, and artificial intelligence in education: A vision for hybrid intelligence. *arXiv preprint*. https://doi.org/10.1111/bjet.13514

Dewi, F. (2024). Leveraging generative AI in ELT: Teachers' integration strategies and pedagogical adaptations. *Journal of Languages and Language Teaching, 13*(2), 89–110. https://doi.org/10.33394/jollt.v13i2.13670

Dilek, M., & Kose, U. (2025). AI literacy in teacher education. *Journal of Teacher Education*.

https://doi.org/10.1177/00224871251325083
Dixon, N., . (2025). Exploring learning analytics practices and their benefits in UK higher education institutions. *Research in Learning Technology, 33*. https://doi.org/10.25304/rlt.v33.3127
Dringó-Horváth, I., Koczy, L., & Kovács, I. (2024). Digital competence and AI literacy among university teachers: Variation by discipline, age, and experience. *Education Sciences, 15*(7), 868. https://doi.org/10.3390/educsci15070868
Efendi, Z., Al Firdha Hanim, M., & Santoso, A. (2025). Kecerdasan buatan (AI) dalam pendidikan: Tinjauan literatur sistematis tentang peluang, masalah etika, dan implikasi pedagogis. *Jurnal Pendidikan, Kebudayaan dan Keislaman, 4*(3), 45–67. https://doi.org/10.24260/jpkk.v4i3.5052
Hershkovitz, A. (2024). Instructors' perceptions of the use of learning analytics for data-driven teaching in online education. *Education Sciences, 14*(11), 1180. https://doi.org/10.3390/educsci14111180
Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial intelligence in education. *International Journal of Artificial Intelligence in Education, 29*(2), 120–134. https://doi.org/10.1007/s40593-019-00184-8
Kim, T. K. (2025). Development of an AI and learning analytics integrated teaching-learning model for STEM education (STELA). *International Journal of Research in STEM Education, 7*(2). https://doi.org/10.33830/ijrse.v7i2.1814
Liu, Y., & Wang, W. (2025). A meta-analysis of empirical studies on learning analytics interventions and student achievement outcomes. *SAGE Open*. https://doi.org/10.1177/21582440251336707
Molla-Esparza, C., García-Ruiz, A., & Fernandez, P. (n.d.). Designing human-centered AI pedagogies: Balancing innovation and equity in higher education. *Education Sciences*. https://doi.org/10.1177/21582440251336707
Morales Tirado, A., Mulholland, P., & Fernandez, M. (2024). Towards an operational responsible AI framework for learning analytics in higher education. *arXiv preprint*.
Muslim, A., Chatti, M. A., & Guesmi, M. (2023). Open learning analytics: A systematic literature review and future perspectives. *arXiv preprint*.
Noviandy, T. R., Idroes, G. M., Paristiowati, M., & Idroes, R. (2025). Techniques and tools in learning analytics and educational data mining: A review. *Journal of Educational Management and Learning, 3*(1), 308–325. https://doi.org/10.60084/jeml.v3i1.308
Prilop, C. N. (2025). Generative AI in teacher education: Educators' perceptions. *Journal of Computer and Education Research, 24*(12), 600–637. https://doi.org/10.18009/jcer.1477709
Sajja, R., Sermet, Y., Cwiertny, D., & Demir, I. (2025). Integrating AI and learning analytics for data-driven pedagogical decisions and personalized interventions in education. *Interactive Learning Environments*. https://doi.org/10.1007/s10758-025-09897-9
Selwyn, N. (2023). Education and AI: Critical perspectives on artificial intelligence in education. *British Journal of Educational Technology, 54*(1), 3–17. https://doi.org/10.1111/bjet.13250
Shi, L., Zhang, H., & Wang, Y. (2025). Assessing teachers' generative artificial intelligence competencies: Instrument development and validation. *Education and Information Technologies, 30*(3), 23365–23384. https://doi.org/10.1007/s10639-025-13684-5
Tan, X. (2024). Artificial intelligence in teaching and teacher professional development: Systematic review. *Computers & Education, 20*, 104612. https://doi.org/10.1016/j.compedu.2023.104612
Vakil, S. (2025). Teachers' generative AI competence: Theoretical foundations and practical implications. *Education and AI Journal, 1*(1), 33–57.
Viberg, O., & Cukurova, M. (2024). What explains teachers' trust in AI in education across six countries. *International Journal of Artificial Intelligence in Education*. https://doi.org/10.1007/s40593-024-00433-x
Yan, L., Sha, L., Zhao, L., Li, Y., Martinez-Maldonado, R., Chen, G., Li, X., & Jin, Y. (2023). Practical and ethical challenges of large language models in education: A systematic scoping review. *arXiv preprint*. https://doi.org/10.1111/bjet.13370
Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education. *International Journal of Educational Technology in Higher Education, 16*, 39. https://doi.org/10.1186/s41239-019-0171-0
Zhou, X., Li, Y., & Chen, G. (2025). Defining, enhancing, and assessing artificial intelligence integration in schools: A systematic review. *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2025.2487538