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AUGUST
2026
RR–26-07

RESEARCH REPORT

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AUTHORS

Teresa M. Ober, Caitlin Tenison, Geoffrey Phelps, Erin Renfrow-Symon,
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ETS Research Report Series ISSN 2330-8516

AI Competencies for Teaching: From Conceptual Frameworks to Enacted Practices

Teresa M. Ober[1], Caitlin Tenison[1], Geoffrey Phelps[1], Erin Renfrow-Symon[1], Jamie N. Mikeska[1], & Vincent J. Dean[2]

[1]ETS Research Institute, ETS, Princeton, New Jersey, United States

[2]ETS Praxis, ETS, Princeton, New Jersey, United States

Abstract

As AI becomes increasingly embedded in educational systems, teachers face new expectations for engaging AI as part of their instructional work and professional responsibilities. This paper argues that clarifying AI competencies for teaching requires more than listing skills: it requires a coherent account of (a) what these competencies involve, (b) how they are enacted in practice, and (c) what evidence can support teacher learning and professional judgment over time. We conceptualize these integrated capacities as *AI competencies for teaching* and distinguish them from broader notions of AI literacy by emphasizing application, professional judgment, and context sensitivity. Drawing on trends in how AI is reshaping teaching, we introduce a framing of AI's roles in education (as tool, content, and context) to specify the instructional demands to which our current understanding of teaching competencies must respond. We then summarize features of existing competency frameworks to surface shared foundations and key tensions related to ethics, technical depth, professional agency, and domain specificity. We describe six interrelated domains of AI competencies for teaching, spanning AI content knowledge, AI technologies, pedagogical integration, ethical awareness, professional judgment and agency, and openness to continuous learning. To illustrate what these competencies look like in use, we present a scenario that makes teachers' instructional decision-making visible when AI is present. Finally, we discuss progress-oriented, evidence-centered approaches, including implications for assessment, that can support teachers' development of these competencies. This work ultimately positions AI competencies for teaching as central to sustaining ethically grounded, responsible, and professionally empowering teaching in AI-mediated educational environments.

Keywords: artificial intelligence, AI, assessment, educational technology, teacher preparation, teacher professional learning, teaching competencies

Corresponding author: Teresa M. Ober, E-mail: tober@ets.org

Author Note

In preparing this manuscript, we used generative AI as an editorial support tool to help identify strategies for improving the organization of ideas, streamlining transitions across sections, and strengthening clarity through copyediting suggestions. All AI-generated suggestions were reviewed by the authors, and final decisions about content, structure, and wording were made by the authors. The authors take full responsibility for the accuracy, originality, and integrity of the final manuscript.

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Part 1: Teaching in the Age of AI: Reasons for Considering AI Competencies for Teaching

AI is rapidly becoming woven into the fabric of education, raising urgent questions about what educators need to know and be able to do to teach responsibly and effectively. As with other internet-enabled digital technologies (e.g., smartphones, tablets), students' engagement is difficult to fully manage through school policies alone. Technologies that are AI enabled make this challenge even more complex because they are not merely discrete tools that can be switched on or off. Rather, they are increasingly embedded within the digital platforms, applications, and systems students encounter in everyday life, often in ways that are not fully recognized. For that reason, attending to how teachers navigate AI-enabled technologies as part of broader learning environments is a central issue in schools today.

Recent syntheses of AI use in K–12 education show a rapidly expanding but uneven evidence base with substantial variation in how AI tools are adopted, interpreted, and integrated into instruction across contexts and grade levels (Fesler et al., 2026; Martin et al., 2024). This uneven uptake is also reflected in surveys and interviews documenting differences in teachers' reported adoption and integration of AI tools (An & James, 2025; Kaufman et al., 2024; Parker & Hayes, 2026). As AI becomes seemingly inseparable from students' everyday lives and learning environments, and from teachers' professional practices, educators must be prepared to engage AI in ways that support students' learning, development, well-being, and agency. Throughout this paper, we treat that commitment as a guiding principle. These capabilities, which we refer to as *AI competencies for teaching,* reflect the knowledge, skills, dispositions, and professional values teachers draw on to make informed, context-sensitive decisions about whether, when, and how AI should be used, or deliberately not used, in the work of teaching and related professional responsibilities.

Why AI Competencies for Teaching Matter Now

Understanding AI competencies for teaching is increasingly important given that several AI-related trends are reshaping the conditions under which teachers support student learning and development. Four such trends include (a) a recognition that students' need whole-person preparation in AI-mediated environments; (b) the increasing influence of AI on pedagogical decision-making; (c) heightened ethical demands surrounding fairness, privacy, and (d) accountability in AI-mediated contexts; and renewed questions about teacher expertise, autonomy, and professional standards.

Today's youth encounter AI from an early age in many different ways: through apps with adaptive features, recommender systems, voice assistants, algorithmically curated content, and increasingly, generative AI tools. Routine engagement with digital media now implies interaction with AI systems that shape what children see, learn, and make sense of (Common Sense Media, 2024; Organisation for Economic Co-operation and Development [OECD], 2023). Younger students, whose educational experiences are mediated far more by algorithmic systems than previous generations, may need access to designed learning opportunities to develop critical awareness of AI's affordances, risks, and social implications (Su & Yang, 2024; Van Brummelen et al., 2021). Without teacher support, students may use AI tools naively or in harmful ways, missing opportunities to learn with and about AI. Given that AI increasingly shapes students' learning and sense-making from early childhood onward, teachers need to be equipped to navigate AI's possibilities and manage its pitfalls so learners today may thrive in the future.

Another trend is the growing need to recognize that AI is already reshaping pedagogical practices by changing how teachers prepare and adapt curriculum, assessment, and instruction. Learning management systems incorporate predictive analytics, and generative AI tools are now easily accessible to students. Teachers must therefore judge when AI meaningfully supports learning, such as by personalizing instruction or providing timely feedback, and when it risks undermining essential instructional goals, such as student creativity, perseverance, agency, or self-regulation. Without pedagogical preparation to guide teachers' instructional decision-making (e.g., lesson design, facilitation, and feedback/assessment), teachers may fall into two extremes: avoiding beneficial tools or ceding too much instructional judgment to opaque algorithmic systems (Kim & Kwon, 2023). When teachers enact effective pedagogical competencies, they remain orchestrators of learning by using AI as assistants to free up time, support differentiated instruction, and potentially render actionable insights about student learning. At the same time, teachers need to have opportunities to develop the knowledge and skills to make sound pedagogical decisions aligned with learners' needs and standards of the profession (Dillenbourg & Jermann, 2010; Holstein & Olsen, 2023). Teachers must actively interpret, adapt, and sometimes constrain AI use so that instructional goals, rather than technological capabilities, drive classroom practices.

A third trend is the heightened attention to ethical considerations as AI systems often reproduce social biases, raise concerns about privacy, and risk exacerbating existing inequities (Gouseti et al., 2025; Tagare et al., 2025). As trusted leaders within communities, teachers are uniquely positioned to help students engage critically with these issues. To do so, teachers must develop the ability to identify when AI systems may perpetuate harm and to support students in understanding how AI can influence attitudes, beliefs, opportunities, and identities (Traga Philippakos & Rocconi, 2025). Addressing these concerns is not ancillary to teaching but central to teachers' moral and civic responsibilities within AI-mediated learning environments. Meeting this ethical imperative also requires systemic support. Questions about data governance, accountability, transparency, and the values embedded in educational technologies cannot fall solely on teachers. From a systems perspective, responsible AI use in education depends on multiple factors including the alignment across curriculum, opportunities for professional learning for teachers, and governance structures (aiEDU, 2025; OECD, 2026).

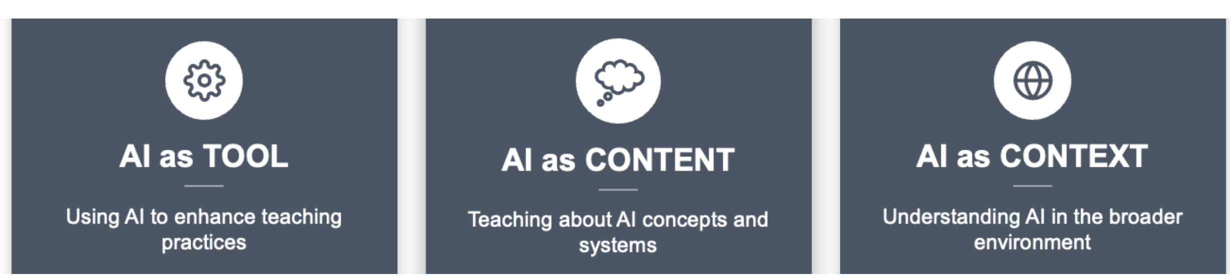
A fourth trend centers on how AI may reshape perceptions and the enactment of teacher autonomy, expertise, and authority. Teaching is a profession grounded in specialized knowledge, particularly situated knowledge gained through experience and professional judgment (Eyal, 2025; Kim & Kwon, 2023). The use of generative AI in education raises ethical, civic, and epistemic concerns that intersect directly with teachers' professional responsibilities, particularly around authority, authorship, and equity (Baidoo-Anu & Ansah, 2023; Trust et al., 2025). It also raises understandable concerns about teacher identity, professional value, and the future of the profession. Without careful consideration of appropriate uses of AI, there is a growing concern that its widespread use could diminish opportunities for teachers to practice and retain key pedagogical knowledge and skills, with the long-term risk of displacing pedagogical decision-making onto automated systems (Daher, 2025; Ravi et al., 2023). Conversely, when teachers understand how AI tools function, how they align with pedagogical purposes, and when they should be adapted or rejected, they are able to exercise their professional agency. AI can elevate the profession by automating routine tasks and providing actionable insights, allowing teachers to focus on higher-level work such as mentoring, interpreting learning data, and supporting students' social-emotional development. In this sense, AI competencies are intended to reinforce, not replace, teacher expertise, with teachers remaining central as interpreters, decision-makers, and professionals who are particularly skilled at attending to the situated, social, and emotional aspects of learning and development. AI competencies are not only about effective tool use, but about sustaining teaching as a profession grounded in expert judgment, relational work, and professional agency in ways that best serve students' learning and development (Aldemir et al., 2025; Popenici & Kerr, 2017).

Different Roles of AI in Teaching: AI as Tool, Content, and Context

The trends outlined above point to a central issue: Educators must learn to navigate a rapidly changing technology landscape shaped by AI. Clarifying what is demanded of teachers requires first making sense of how AI intersects with the work of teaching itself (Lucas & Lioy, 2025). Unlike earlier technological shifts in education, such as the advent of the personal computer (Dede & Allen, 1981) or the rise of the internet (Roschelle et al., 2000), the current transformation is marked by the multifaceted, ubiquitous presence of AI, particularly generative AI. AI now simultaneously functions as subject matter to be understood, a tool that shapes instruction and professional work, and a persistent feature of the broader social and informational environments in which teaching and learning occur. Recognizing these distinct but overlapping roles helps explain why the challenges arising from the trends previously described are not isolated, but complex and deeply embedded in everyday educational practice.

Reflecting this complexity, we further recognize that AI is not a single object of practice, nor does it enter classrooms in uniform ways. Rather, it simultaneously operates as a set of tools that can support instructional work, as something students are expected to learn about, and as an increasingly pervasive feature of the environments in which teaching and learning occur. To clarify this complexity, we propose three vastly simplified and interrelated roles of AI in teaching and learning environments: *AI as tool*, *AI as content*, and *AI as context* (see Figure 1).[1] Table C1 in Appendix C shows how these different roles might intersect with particular teaching moves.

Figure 1. Simplified Roles of AI in Teaching



AI as Tool

When AI is treated as a tool, it functions as a support for pedagogical practice, encompassing uses that assist teaching for the sake of students' learning and development. This role foregrounds AI's increasing influence on instructional planning, creation of materials, feedback, assessment, and workflow. From this perspective, students' AI tool use in classroom settings could be viewed, at least in part, as an extension of teachers' instructional decisions and the types of classroom norms teachers set concerning classroom technology use.

Building on Prilop et al.'s (2025) distinction between AI tools primarily used by students and those primarily used by teachers, we acknowledge a conceptual difference between "AI as a teaching tool" and "AI as a learning tool." However, because both of these purposes are embedded within teaching practices, we instead adopt the combined role of "AI as tool." This framing shifts emphasis from *who* uses the tool to *why* it is used, recognizing that teachers are often responsible for selecting AI tools for both teaching and learning. Furthermore, many digital tools such as adaptive tutoring systems or automated assessment platforms can be understood as supporting both teaching and learning in integrated ways (Zhang & Zhang, 2024).

Framing AI as a tool also helps clarify questions of access or efficiency. While AI systems are often promoted for productivity or personalization, their educational value depends on how they are aligned with instructional purposes and learning goals (Chiu, 2025a). Viewing AI as tool also helps to highlight issues of accountability and agency. When AI mediates instructional work, responsibility for instructional decisions remains with teachers, even when aspects of practice are automated (Dogan et al., 2025). AI can extend teachers' capacity to design learning experiences and manage instructional demands, but uncritical reliance risks narrowing instructional goals, obscuring limitations or bias in AI outputs, or shifting decision-making away from teachers' expertise (Chiu & Chai, 2020; Chiu & Sanusi, 2024). In this regard, a teacher's orientations toward AI tools matters. Empirical studies indicate that teachers' uptake of AI tools may be shaped less by tool availability alone than by teachers' confidence, trust, and perceived alignment of the tool with instructional goals (Demszky & Liu, 2023; Kaplan-Rakowski et al., 2023; Viberg et al., 2025).

AI as Content

When AI is treated as content, instruction focuses on supporting students' understanding of how AI systems work and how their outputs should be interpreted. Students are more exposed to AI systems than ever before and in ways that appear to fundamentally shape information access, decision-making, and opportunity structures across contexts. As a result, students need opportunities to engage with core ideas such as data, algorithms, model behavior, uncertainty, and system limitations and to develop the capacity to critically evaluate AI-generated outputs rather than accept them at face value (Van Brummelen et al., 2021; Velander et al., 2024). Framing AI in this way highlights that meaningful understanding develops over time and varies across age levels and disciplinary contexts, underscoring the need for sustained and developmentally responsive engagement with AI as an object of learning (Chakraburty et al., 2025; Shi et al., 2024; Sparks et al., 2024).

AI as Context

When AI is treated as context, it is understood as part of the broader sociotechnical environment that shapes how students encounter information, communicate, and make sense of the world across digital and physical spaces. Viewing AI in this way foregrounds several of the AI-related trends in teaching noted previously, particularly in recognizing that students already engage with AI-mediated systems well beyond formal instruction and often outside the direct control of schools (Yetisensoy & Rapoport, 2023). From this perspective, AI is already embedded in the conditions of teaching and learning (Ng et al., 2024), shaping expectations, opportunities, and risks regardless of whether it is explicitly addressed in curriculum or instructional design. At the same time, students bring their experiences with AI from this broader context into schools and classrooms, effectively making these experiences part of school-based teaching and learning.

Viewing AI as context helps explain why the challenges raised by the AI-related trends described previously are systemic rather than isolated. Students routinely interact with generative AI, algorithmically curated information, and AI-driven systems that influence how knowledge, authorship, credibility, and fairness are understood, often in ways that are opaque or misaligned with educational goals (Velander et al., 2024; Walsh et al., 2024). At the same time, teachers operate within evolving policy and governance environments related to data privacy, accountability, transparency, and academic integrity, where guidance is often uneven or rapidly changing (Kundu et al., 2025; OECD, 2025b; TeachAI, n.d.).

Foundations of AI Competencies for Teaching

As described above, AI now enters classrooms simultaneously as a tool that shapes instructional work, as content that students are increasingly expected to understand, and as a part of the broader context that influences how people encounter information and participate in digital life. At the same time, we recognize this framing is a simplification and these roles frequently overlap in practice, particularly as emerging AI systems become more interactive and agentic. Even when AI appears to operate as a collaborator or to co-construct knowledge, these processes may be viewed as remaining embedded within systems based on goals created by and responsibilities assigned to *humans* who serve as the primary agents (see Engeström, 2001). With this in mind, we recognize teachers as key agents in instructional systems, setting goals and taking responsibility for directing AI use in the service of student learning and development.

Teachers therefore need more than awareness of the various roles of AI, but rather, a solid foundation for understanding, evaluating, and using information derived from AI responsibly. Such competencies have been broadly referred to as AI literacy. There has been significant work focused on defining AI literacy for K–12 students, offering useful guidance for what students should know and be able to do with AI (Chakraburty et al., 2025; OECD, 2025a; Sparks et al., 2024; Tan & Tang, 2025). More precisely, AI literacy refers to foundational capacities to understand how AI systems work, critically evaluate their outputs, and recognize ethical and societal implications (Ng et al., 2026; Sparks et al., 2024; Zhou et al., 2025). One common framing describes four dimensions of AI literacy: (a) knowledge of AI concepts; (b) use of AI tools; (c) evaluation of outputs and limitations; and (d) ethics and responsible engagement (Ng et al., 2024). Building on such work, Chakraburty et al. (2025) define AI literacy as "the ability to understand, interact with, and responsibly use AI systems to access, manage, and create information to make ethical, informed decisions" (p. 9).

Beyond possessing foundational AI literacy skills, teachers are also expected to exercise pedagogical judgment about how to integrate AI, maintain confidence in experimenting with evolving tools, and reflect on their instructional decisions when using AI in relation to instructional goals and ongoing professional learning (Younis, 2025a). Thus, while AI literacy establishes essential capabilities in information and communication contexts, AI competencies capture the multidimensional, adaptive, and practice-oriented capabilities required for effective and responsible AI integration into teaching. With that in mind, we treat *AI literacy* as an essential foundation while reserving *AI competencies for teaching* for the domain-specific application of that foundation in professional practice. In other words, teachers' capacity to leverage their knowledge, skills, and dispositions to make context-sensitive instructional and professional judgments about when and how AI should (or should not) be used (Zhou et al., 2025). This distinction parallels that suggested by Falloon (2020), who contrasted digital literacy from a broader set of digital competencies.

Although there is some emerging clarity concerning around students' AI literacy, expectations for exactly what teachers should know and be able to do with AI in their professional role remain less clear. Without an account of competencies teachers need in order to engage AI in their work, it is difficult to ensure the instructional, ethical, and organizational conditions under which students can develop AI literacy and other key capabilities for them to thrive in the future.

Aims and Organization

Ongoing ambiguity around teacher competencies involving AI, coupled with increasing urgency to guide student learning amid the multiple and evolving roles of AI in instructional settings, motivates us to bring this issue into central focus. The AI-related trends noted previously, which center on supporting students' learning and development, ensuring pedagogical appropriateness, enabling ethical and informed instructional decision-making, and upholding professional values, help to clarify why action is needed now. At the same time, the possibility that AI could function simultaneously as tool, content, and context helps to explain why navigating the presence of AI in teaching and learning contexts is not a simple matter with a straightforward solution.

Together, these observations point to the need to clarify what it means for teachers to engage AI productively and responsibly, and how the AI competencies for teaching reflected in such engagement can be recognized and cultivated. Addressing this requires moving toward a clearer account of the types of competencies for teaching needed to enact responsible, student-centered practices in AI-mediated learning environments. Toward this, the remainder of the paper examines AI competencies for teaching as applied, observable, and learnable capabilities. The discussion that follows is organized around three interrelated questions.

The first question, ***What are the most essential AI competencies for teaching?***, is taken up in Part 2. To address this question, we review existing frameworks that define AI-related competencies for educators, distilling key themes and theoretical foundations that shape current understandings of what teachers need to know and be able to do when engaging AI (in its various roles) through the work of teaching.

The second question, ***How could teachers demonstrate evidence of AI competencies for teaching?***, is the focus of Part 3. Here, we examine how AI competencies are enacted in classroom and professional contexts, with attention to how they translate into instructional practices. This section explores guiding principles for human–AI collaboration and highlights sources of variation in how AI competencies for teaching are expressed depending on the roles of AI and teachers' subject areas, educational settings, and career stages.

The third question, ***How could evidence of AI competencies for teaching support teachers' professional growth?***, is addressed in Part 4. In this section, we consider implications for assessment, certification, and professional learning, examining approaches to documenting and evaluating AI competencies for teaching in ways that facilitate, rather than constrain, teachers' professional development. We also discuss the broader existing and systemic conditions that could shape whether meaningful competency development is possible.

Distinguishing the roles of AI provides a framework for the sections that follow, allowing us to examine important features of how AI competencies are conceptualized (Part 2), enacted in practice (Part 3), and ultimately assessed and supported (Part 4), thus serving as a common lens. The paper then concludes by summarizing key insights and outlining implications for research, policy, and practice (Part 5). Throughout, we position AI competencies for teaching not as a new set of discrete skills, but as an opportunity to better understand how educators can support student-centered teaching and learning within an AI-integrated educational landscape. Ultimately, we strive to identify competencies for teaching that are likely to prioritize students' autonomy, well-being, and meaningful learning over technological convenience or efficiency, placing an emphasis on the ways AI could augment rather than replaces teachers' professional judgment and relational work.

Part 2: Conceptualizing AI Competencies for Teaching

The varied roles AI plays in educational settings motivate closer examination of how existing competency frameworks conceptualize what teachers must know and do in AI-mediated teaching environments. With this in mind, we address the first guiding question (*What are the most essential AI competencies for teaching?*) by considering how existing frameworks conceptualize AI competencies for teaching, focusing on what forms of knowledge, skills, and dispositions they emphasize when AI is involved in teaching. Through a review of distinct perspectives on this topic, both shared foundations and important points of divergence can be surfaced, helping to specify what features are considered (and contested) as central aspects of AI competencies for teaching.

Existing Perspectives on AI Competencies for Teaching

As interest in teachers' AI-related knowledge and skills has grown, various AI competency frameworks have emerged to guide research, policy, teacher preparation, and professional development (see Mikeladze et al., 2024, for a review). Our goal for this section is not to provide an exhaustive catalog of AI competency frameworks for teaching; rather, it is to illustrate how different frameworks conceptualize teacher AI competencies and the varied ways that reflect certain assumptions and implications related to supporting teacher preparation, professional growth, and responsible AI integration in educational settings.

We focus on four frameworks, each purposively selected to examine how AI competencies for teaching are defined when frameworks reflect different orientations and intended uses. In particular, one type of framework representing an extension of an existing theoretical approach augmented to incorporate AI capabilities (AI-TPACK frameworks; see Celik, 2023; Chiu, 2025b) was selected because it builds on a well-established theoretical and empirical tradition for conceptualizing competencies for technological integration in instructional settings. Another framework was included because it has potential for a wide international policy impact and is positioned to shape policy guidance and investment across education systems (United Nations Educational, Scientific and Cultural Organization [UNESCO] Global AI Competency Framework for Teachers; Miao & Čukurova, 2024). Another framework was included which uniquely concentrates on higher education and specifies parallel AI literacy and related competencies for students and faculty (Digital Education Council [DEC], 2025). Although this review primarily focuses on K–12 settings, we include this framework to surface how competency expectations could differ or be aligned across the roles of learners and teachers, as well as K–12 and higher education institutional contexts. The fourth framework focused on competencies for individual learners and teachers, as well as the system conditions that connect learners, teachers, and school communities and which enable teachers' competencies in using AI to be developed and enacted (aiEDU, 2025).

Theory-Oriented Approaches: TPACK Variations

As documented by Mikeladze et al. (2024), several approaches to conceptualizing AI competencies for teachers build on existing theoretical models, particularly the Technological Pedagogical Content Knowledge framework (TPACK; Mishra & Koehler, 2006). Accordingly, TPACK posits that effective technology integration requires blending technology knowledge (TK) with pedagogical knowledge (PK) and content knowledge (CK). Such approaches tend to emphasize AI as a tool for teaching and learning, extending teachers' technological and pedagogical knowledge while engaging AI as content to a more limited extent and addressing contextual concerns implicitly through ethical integration of AI into teaching within a given context.

Celik (2023) and Chiu (2025b) each propose distinct AI-specific TPACK variants. Given both of these approaches draw from the TPACK framework, we refer to them collectively as "AI-TPACK" approaches. In Celik's Intelligent-TPACK framework, AI-related competencies for teaching are described in categories including

- AI-TK: knowledge of AI tools and how to operate them;
- AI-PK: knowing how to teach effectively with AI support; and
- AI-CK: understanding how AI intersects with subject content.

These models also add new domains that deviate from the original TPACK model by including components that reflect

- ethics knowledge (Celik, 2023): considering issues like bias and transparency as part of their technological understanding; and
- human–AI collaboration knowledge (Chiu, 2025b): using AI systems alongside one's own judgment to inform teaching.

Importantly, some AI-TPACK models emphasize not just the AI-specific competencies for teaching, but also their intersections (e.g., Celik, 2023, Figure 1), whereas other approaches tend to focus more on the primary domains for simplicity (e.g., Chiu, 2025b, Figure 1). This raises a key question about which and how many specific competencies need to be acknowledged as key aspects of AI competencies for teaching.

Aspects of the AI-TPACK approaches appear to have some empirical grounding. For example, Kim and Kwon (2023) administered surveys ($N = 67$) and conducted interviews ($N = 13$) with elementary teachers in Korea, and the authors found that the 22 key AI competencies for teaching that teachers identified could largely be mapped onto the main categories of the TPACK framework (i.e., technological content, pedagogical, and content knowledge). The authors also found that many teachers felt weakest in the technological and ethical aspects of AI integration. That insight aligns with the AI-TPACK emphasis that those domains may need more attention in training. Furthermore, by explicitly including ethics, both AI-TPACK frameworks emphasize that shared values and ethical and societal considerations should be included as part of good teaching with technology (see also Ocak & Çaskurlu, 2025).

Overall, AI-TPACK frameworks bring an evidence-informed basis to the discussion of AI competencies and ensure integration into existing teacher knowledge structures. At the same time, further research is needed to apply such frameworks to teaching practices and evaluate the efficacy of teacher professional trainings organized around such frameworks (Celik, 2023; Rui et al., 2025).

Policy-Oriented Approach: UNESCO Framework

UNESCO is a United Nations agency that works to advance international cooperation in education, science, culture, and communication in support of peace and sustainable development. The *UNESCO Competency Framework for Educators* (Miao & Čukurova, 2024), hereafter, "UNESCO framework," offers an expansive framework to define AI competencies for teaching and includes

- human-centered values: keeping teaching rooted in human rights, well-being, and inclusion even as AI is used;
- ethics of AI: understanding ethical principles and ensuring AI use is fair, transparent, and accountable;
- AI knowledge: foundational understanding of AI technologies and concepts;
- AI pedagogy: skills to integrate AI tools into instructional design and classroom practice; and

- professional development: continuously learning and collaborating with others as teachers, even as AI technologies evolve.

The UNESCO framework has a broad scope, encompassing not only knowledge and skills but also dispositions that reinforce normative, human-centered values for conceptualizing responsible engagement with AI in teaching contexts. It emphasizes human oversight and equity, stressing that teachers should use AI to enhance teaching and that they champion inclusive practices (Miao & Čukurova, 2024). In this regard, this framework is attentive to AI as context, foregrounding ethical, societal, and governance considerations, while also addressing AI as content through foundational knowledge and as a tool through pedagogical application.

Higher-Education Faculty Approaches: Digital Education Council Framework

The DEC is a global membership organization based in Europe, consisting of higher-education leaders focused on advancing responsible digital technology use in higher education (DEC, 2025). We draw on the DEC framework to illustrate how a model can specify aligned expectations across learners and educators, an issue likely to be relevant for K–12 systems seeking coherence across student-facing AI and teacher-facing competencies related to AI. The DEC (2025) framework includes the same five domains and associated prompts for both students and higher education faculty.

- Understanding AI and Data: How does AI work?
- Critical Thinking and Judgment: How do I evaluate AI output?
- Ethical and Responsible Use: How do I ensure AI is used ethically and responsibly?
- Human-Centricity, Emotional Intelligence, and Creativity: How do I ensure humans remain at the core?
- Domain Expertise: How do I apply AI in a specific context?

The DEC (2025) framework also identifies distinct criteria for both the role of student and that of faculty. For example, under the first domain (Understanding AI and Data), the framework notes that “students should be able to use AI tools for learning, research, and productivity, and understand AI limitations and biases,” while the complementary criteria for faculty indicates that "[they] should be experts in rigorously evaluating AI-generated output, and be able to assess AI's impact on human cognition."

Through a professional development partnership where teacher educators and practicing teachers collaboratively explored AI tools and shared reflections, Kelley and Wenzel (2025) used the DEC framework as a guiding structure to support learning for K–12 teacher candidates and college faculty. By incorporating critical reflection as a core component, their work acknowledges that educators may develop competencies related to AI not just by acquiring knowledge, but also by actively experimenting and reflecting on their experiences. As described by Kelley and Wenzel (2025), participating teachers engaged in cycles of experimenting with an AI application in their teaching then discussing what worked or what ethical dilemmas arose.

Viewed through the roles of AI (i.e., as tool, content, context) introduced earlier, their framework places particular emphasis on AI as a tool for teaching and professional learning, using cycles of experimentation and reflection to support instructional decision-making (Kelley & Wenzel, 2025). At the same time, its focus on ethical reasoning and institutional opportunities and partnerships for educator learning positions AI as context, shaping the professional norms and conditions within which teaching and learning occur, while engagement with AI concepts and data support AI as content in domain-specific ways (Kelley & Wenzel, 2025).

Person-Within-Systems Approaches: aiEDU Framework

The aiEDU (2025) AI Readiness Framework offers a practice-driven model that articulates what students, educators, school leaders, and districts need to know and be able to do in an AI-infused educational landscape. aiEDU is a U.S.-based nonprofit that develops AI education resources and guidance for K–12 communities. This particular framework emphasizes observable behaviors tied to responsible use, critical evaluation of AI tools, and the development of capabilities such as emotional intelligence, creativity, and interdisciplinary thinking. It is organized into competency domains for students:

- Know and Model Basics
- Be a Critical Thinker
- Lead with the Human Advantage

And it includes parallel domains for educators:

- Know and Model the Basics
- Foster and Model Critical Thinking
- Lead with the Teacher Advantage

The aiEDU framework positions itself as practice-embedded and implementation-focused, offering examples of educator behaviors and role-specific competencies. It includes grade-banded student progressions, teacher-facing instructional behaviors, and general rubrics for leaders, making it a potentially action-oriented tool for educators as well as school and district leaders. The framework further distinguishes itself by providing School Leader- and District-level AI Readiness Rubrics that outline progressions (*Demonstrate Commitment*, *Invest & Implement*, *Deepen & Iterate*) across areas such as policy guardrails, instructional leadership, procurement processes, and community engagement. This approach positions readiness not as an individual challenge but as a coordinated effort across the educational ecosystem that articulates what students, educators, school leaders, and districts need to know and be able to do in an AI-infused educational landscape.

The aiEDU framework further attempts to center what educators and leaders already do as part of their profession and how such good practices could be evidenced through behaviors including: how to evaluate AI tools, how to perform credibility checks, integrate AI responsibly, and generally support learning and development. Furthermore, the aiEDU framework recommends readiness structures that could guide decisions around professional learning activities for teachers, enabling some degree of coherence across classrooms, schools, and districts. In this regard, the aiEDU framework explicitly spans all three roles, positioning AI as content for student learning, as a tool for instructional practice, and as context through its attention to system-level readiness and institutional conditions.

Common Themes From Frameworks

Across the literature reviewed, including the four frameworks described above, several consistent common themes emerge. Although frameworks of AI competencies for teaching may differ in scope, audience, and intended use, they are not conceptually fragmented. The four focal frameworks serve as illustrative anchors, and the themes described are reinforced by a wider body of scholarship examining what teachers need to engage AI responsibly and productively in educational contexts. We summarize these themes reflecting convergence below, drawing on both the focal frameworks and the broader literature reviewed for this paper.

Theme #1: Foundational technical understanding of AI as a prerequisite for informed use

The first theme is that teachers require a foundational level of technical understanding of AI systems in order to use them responsibly and critically. Across frameworks and studies, this knowledge is framed not as developer-level expertise, but as conceptual understanding of how AI systems are trained, what kinds of outputs they generate, and where their limitations and risks lie (Laru et al., 2025; Mikeladze et al., 2024; Ng et al., 2024). The UNESCO framework (Miao & Čukurova, 2024), for example, identifies AI knowledge as a core competency dimension for all teachers, underscoring that even computer science nonexperts should understand basic concepts such as data, algorithms, and model behavior. Empirical studies similarly show that gaps in this type of knowledge may limit teachers' ability to evaluate AI tools, interpret outputs, or explain AI-related phenomena to students (Ding et al., 2024; Kundu et al., 2025). Across the literature, some technical understanding may function as an enabling condition: without a basic understanding of how AI systems work, one's capacity to exercise ethical reasoning, and potential to demonstrate pedagogical integration related to using such systems may be inconsistent.

Theme #2: Pedagogical integration that reinforces, rather than replaces, high-quality teaching

A second theme is that AI competencies for teaching are fundamentally pedagogical in nature. Frameworks generally emphasize that knowing about AI is insufficient unless teachers can integrate AI tools in ways that align with instructional goals, disciplinary practices, and students' learning needs. This orientation is visible in UNESCO's AI-Pedagogy dimension, in the emphasis of the AI-TPACK variations on blending AI knowledge with pedagogical and content knowledge (Celik, 2023; Chiu, 2025b), and in practice-oriented research on AI-supported instructional design (Dogan et al., 2025; Kelley & Wenzel, 2025). Across these sources, AI is positioned as a means of augmenting core teaching practices, such as formative assessment, differentiation, and feedback, rather than as a substitute for professional judgment. This theme aligns with broader scholarship on effective teaching, which consistently finds that instructional quality depends on teachers' decisions and interactions, not on tools alone (Sykes & Wilson, 2015). AI competencies, from this perspective, are best understood as extensions of established pedagogical expertise applied to seemingly new AI-facilitated contexts.

Theme #3: Ethical and human-centered judgment as an integral dimension of competence

A third theme emphasizes the centrality of ethical reasoning and human-centered judgment in AI-integrated teaching. Across frameworks and empirical studies, teachers are expected to attend to issues of fairness, transparency, privacy, and student well-being when considering whether and how to use AI systems (Tagare et al., 2025). Although frameworks differ in how explicitly they foreground ethics, they each appear to emphasize that teachers should not treat AI outputs as neutral or authoritative but instead interrogate their implications for learners and learning environments.

Research on teachers' perceptions of AI suggests that ethical concerns strongly shape teachers' willingness to adopt AI tools (von Gillern, 2025; Yim & Wegerif, 2024). In particular, teachers' engagement with AI has been found to surface concerns about bias, representation, and civic reasoning, underscoring ethical awareness as integral to responsible AI use in teaching (Baidoo-Anu & Ansah, 2023; Trust et al., 2025; Yu & Li, 2026). Guidance on AI competencies in teacher education further recommend modeling how to question reliability, scrutinize bias, and set clear expectations for responsible student use (e.g., authorship with appropriate attribution, permissible assistance), reinforcing equity and trust (Kelley & Wenzel, 2025; Lucas et al., 2024; Pretorius, 2023).

Theme #4: Professional agency and confidence to exercise judgment over AI

A fourth theme emphasizes the importance of teacher agency, professional confidence, and well-being in AI-integrated contexts. Multiple studies document that teachers often feel underprepared, uncertain, or ambivalent about AI, which can lead either to avoidance or to uncritical adoption (Al-Abdullatif, 2025; Kim & Kwon, 2023). In response, frameworks emphasize that AI competencies should empower teachers to make informed decisions, override or reject AI recommendations when necessary, and assert their expertise as educators. The UNESCO framework (Miao & Čukurova, 2024), for instance, explicitly frames AI competence as a means of enhancing human agency rather than diminishing it. Practice-focused scholarship similarly argues that teachers must "own" AI tools, understanding their affordances and constraints, if those tools are to support, rather than constrain, professional practice (Dogan et al., 2025). Across the literature, confidence and agency emerge as both outcomes of competency development and prerequisites for meaningful AI integration. When teachers retain authority over whether, when, and how AI is used, they are better positioned to avoid forms of AI adoption that increase burden, erode professional identity, or undermine situated and nuanced aspects of teaching.

Theme #5: Continuous learning and adaptation in a rapidly evolving landscape

A fifth and final theme reflects an emphasis on ensuring teachers have opportunities for continuous learning and adaptation, particularly given the rapid pace of AI development. As such, AI competencies need to be framed as evolving capacities supported through professional learning, collaboration, and reflective practice (Sagheem et al., 2025; Zhou et al., 2025). The inclusion of AI for professional learning in the UNESCO framework (Miao & Čukurova, 2024) highlights this expectation explicitly, whereas empirical research underscores the value of peer learning communities, low-stakes experimentation, and iterative professional development in building competencies relevant now and likely to be so in the future (Pei et al., 2025; Younis, 2024). In this way, AI competencies for teaching are developmental and context-sensitive, shaped over time through practice rather than acquired once and for all.

Cross-Framework Divergences and Related Considerations

Although existing frameworks converge on several core themes, this convergence does not imply consensus on how AI competencies for teaching should be organized or operationalized. Instead, frameworks reflect different design choices with implications for how teachers are prepared to engage with AI. These divergences are best understood *not* as disagreements or omissions, but as consequential decisions that shape how AI competencies are defined, enacted, and assessed in practice. We highlight several such considerations below to surface choices that users may face when adopting any specific framework of AI competencies for teaching.

Consideration #1: What depth of technical knowledge is required: conceptual understanding or technical mastery?

The level of technical knowledge expected of teachers may differ between frameworks. Some emphasize conceptual understanding sufficient for informed classroom use, particularly for teachers outside computer science and related subject areas (Miao & Čukurova, 2024); others foreground deeper technological knowledge, such as understanding how AI systems operate and are constructed (Chiu, 2025b). Furthermore, empirical work suggests substantial variation in teachers' AI knowledge and confidence, with misconceptions about AI remaining common (Ding et al., 2024; Ning et al., 2025; Pei et al., 2025). This raises a key design question: whether AI competencies should prioritize broadly distributed conceptual understanding or differentiated depth aligned to role, context, or subject area (Long & Magerko, 2020).

Consideration #2: How should ethics be incorporated into the framework: as a stand-alone domain or embedded throughout?

Frameworks may differ in whether ethical reasoning is treated as a distinct competency domain or embedded across pedagogical and technological competencies. For example, UNESCO positions ethics as a core domain, signaling the importance of explicit ethical learning progressions (Miao & Čukurova, 2024), whereas AI-TPACK–based approaches emphasize ethical judgment as integral to all AI-related teaching decisions (Chiu, 2025b). Related scholarship similarly frames ethics as an overarching mindset rather than a discrete module (Tagare et al., 2025). This divergence reflects a design choice about whether to foreground ethics through visibility or integration, or to combine both approaches.

Consideration #3: What role should teachers play in designing how AI is used for learning: critical decision-makers or system co-developers?

Across frameworks, teachers are generally positioned as decision-makers who select, evaluate, and adapt AI tools for instructional purposes rather than as system developers (Celik, 2023; Chiu, 2025b). However, expectations vary regarding the extent of the teachers' role and involvement in shaping the AI systems they use. Some frameworks envision greater participation in policy development or system-level customization at advanced levels (Miao & Čukurova, 2024), whereas others emphasize more bounded responsibilities, such as curating AI outputs and structuring activities that support students' critique of AI (aiEDU, 2025; Kelley & Wenzel, 2025). This divergence surfaces unresolved questions about responsibility and accountability when AI tools fall short in practice.

Consideration #4: At what level of specificity should AI competencies for teaching be defined: broadly applicable or subject- and context-specific?

Finally, frameworks may differ in whether AI competencies for teaching are framed as broadly applicable across subjects and grade levels or as meaningfully shaped by disciplinary knowledge and context. Global frameworks tend to emphasize domain-general competencies (e.g., Miao & Čukurova, 2024), whereas others explicitly incorporate domain expertise and subject-specific pedagogical knowledge for AI (e.g., Dogan et al., 2025; Kelley & Wenzel, 2025). The resulting tension concerns whether teacher learning and assessment should begin with a shared foundation that is later contextualized or whether subject specificity should be embedded from the outset. Many frameworks implicitly adopt a hybrid approach that combines both.

Summary: Creating A Foundation for Observable AI Competencies for Teaching

The frameworks described above help articulate what AI competencies for teaching entail, offering complementary perspectives shaped by their intended purposes and audiences. In general, they each emphasize the integration of some understanding of how AI systems work along with pedagogical judgment, ethical reasoning, professional agency, and ongoing learning. These frameworks also reflect a shared commitment to human-centered teaching rather than technology adoption for its own sake. From this perspective, AI competencies for teaching, like more general competencies for teaching (see Snoek et al., 2019), are best understood as multifaceted and judgment laden.

At the same time, there remains somewhat of a disconnect in understanding how these competencies may be interpreted as visible and distinguishable in the everyday work of teaching. This limitation creates a practical challenge for research, assessment, and professional learning: Without an account of how such competencies are enacted by teachers, they remain conceptually defined but empirically underspecified. Addressing this challenge requires shifting attention from definitions alone to the patterns of instructional decision-making through which AI competencies for teaching are expressed in context.

In the next section, we seek to address this gap by examining how AI competencies for teaching are enacted and inferred from patterns of instructional decision-making, rather than from isolated behaviors or specific uses of AI.

Part 3: Making AI Competencies for Teaching Visible

Having outlined common themes and tensions across select frameworks of AI competencies for teaching, we now explore what it looks like when teachers integrate and apply knowledge of AI into their work. Although existing frameworks clarify what teachers may need to know about AI, they often stop short of specifying how these competencies are enacted, mediated, or evidenced in day-to-day instructional practice (Martin et al., 2024). Our goal in this section is to bridge conceptual accounts of AI competencies for teaching with the types of observations[2] we might expect when such competencies are enacted in teaching. Through this inquiry, we address the second guiding question (*How could teachers demonstrate evidence of AI competencies for teaching?*) by illustrating how AI competencies for teaching become visible through the types of situated decisions and actions teachers make based on specific instructional goals.

Recognizing AI Competencies for Teaching Amidst Contextual Variation

Observing AI competencies for teaching is inherently shaped by the complex nature of teaching. As described in Part 1, AI enters teaching in multiple, overlapping ways: as an instructional tool, as content to be taught, and as part of the broader learning environment. When AI functions as a tool (as a resource for instructional tasks), evidence may include how teachers select, adapt, monitor, or deliberately reject AI tools in light of learning goals and how they use it to apply high-leverage instructional practices. When AI functions as content (as an object of disciplinary inquiry), evidence may include how teachers explain AI concepts, address student misconceptions, or engage students in examining the ethical and societal implications of AI systems. When AI functions as context (as a feature of the broader learning environment), evidence may include how teachers establish norms for responsible use, navigate institutional constraints, or communicate transparently with students and families about AI's role in the classroom. Furthermore, given these roles of AI frequently co-occur, surface features of instruction, such as whether a teacher uses an AI tool, may provide insufficient evidence of AI competencies for teaching. For example, teachers may demonstrate strong AI-related competencies through principled non-use when involving AI in teaching is misaligned with instructional goals.

In addition to recognizing the various ways AI enters the classroom, another central challenge in observing teachers' demonstrations of AI competencies for teaching is the variability across developmental levels of students, subject areas, teachers' individual readiness, and instructional contexts. In early childhood settings, AI competencies for teaching may be expressed through mediation, boundary-setting, and developmentally appropriate explanation rather than tool use alone (Su et al., 2023; Su & Yang, 2024). At later grade levels, teachers may directly integrate AI into disciplinary learning or engage students in examining the ethical and societal implications of AI in subject-specific ways (Walsh et al., 2024). Classroom-based studies in science and elementary STEM contexts, for example, have illustrated that AI tools function differently across subjects and age levels (Lee & Zhai, 2024; Memari & Ruggles, 2025). These differences reflect students' developmental readiness as well as disciplinary norms, underscoring that AI competencies for teaching cannot be evaluated against a single, universal model of practice. Teachers' experience, prior exposure to technology, and professional learning opportunities also shape teachers' readiness to enact these competencies. Teachers' confidence in using AI systems constrains their willingness to use such tools, even when they are perceived as potentially useful (Kim & Kwon, 2023; Sperling et al., 2024; Tan et al., 2025; Whalen et al., 2025; Yim & Wegerif, 2024). Furthermore, institutional conditions, including access to devices, internet connectivity, approved tools, and policy guidance, shape what AI-competent teaching looks like in practice (Common Sense Media, 2024; Diliberti et al., 2024). Even so, in contexts where AI technology use is more limited, teachers may enact AI competencies through discussion, critique of AI-generated media, or "unplugged" activities that emphasize AI as a societal context rather than a classroom tool (Kundu et al., 2025).

Given all of these sources of variability, we recognize that enactment of AI competencies for teaching is context dependent, and meaningful observation may require attention to patterns of instructional decision-making reflect how teachers interpret, adapt, constrain, or deliberately reject the roles of AI in the classroom in light of sound pedagogical, ethical, and contextual considerations. The challenge, therefore, is to capture evidence of a set of core AI competencies that are applicable across different contexts.

Toward Observable AI Competencies for Teaching

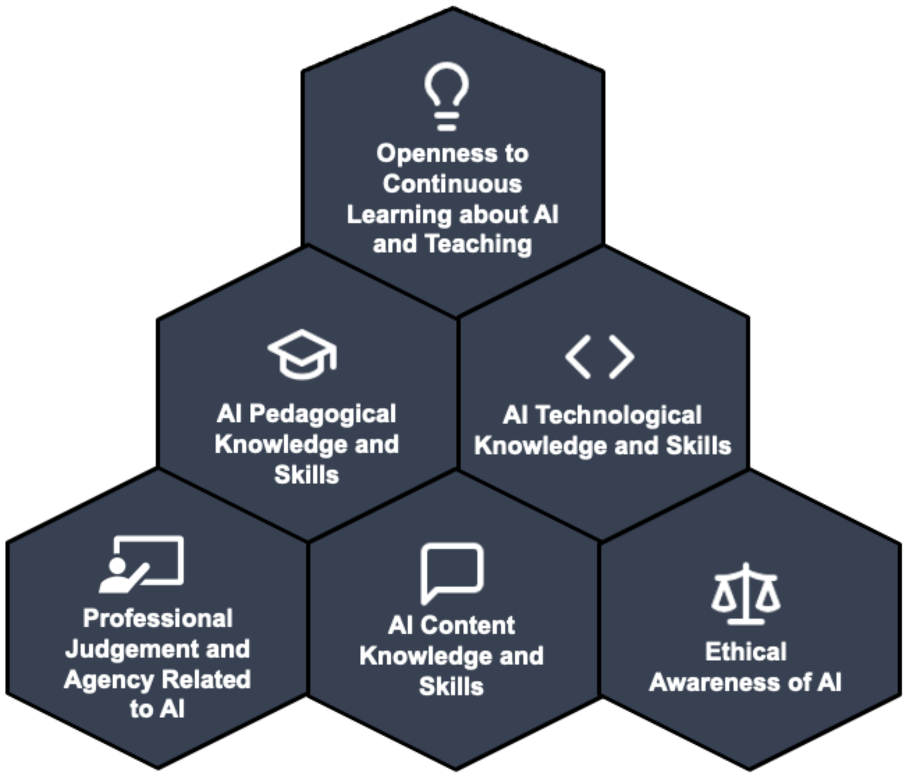
In light of this context-dependent variability and the need to attend to patterns of instructional decision making, we leverage the common themes identified in Part 2 to clarify what constitutes AI competencies for teaching. Across each of the frameworks on AI competencies for teaching described in the prior section, there was a recognition of the importance of supporting teachers' foundational understanding of AI, nurturing competencies that facilitate pedagogical integration to reinforce high-quality teaching, emphasizing the centrality of ethical and human-centered judgment and professional agency, and ensuring environments that reinforced a commitment to continuous learning. Based on these themes, we organize observable practices around six interrelated domains of AI competencies for teaching. Table C2 in Appendix C shows alignment between the common themes from Part 2 and the proposed domains of AI competencies for teaching. Each of the five themes noted in Part 2 is reflected in one of the competency domains, with one exception. Although AI content does not emerge as a standalone common theme in the framework review, we recognize it is essential to include it as a distinct competency domain because teaching is inherently about content, and teachers increasingly bear responsibility not only for teaching with AI, but also for teaching about AI in developmentally, disciplinarily, and ethically grounded ways.

These competency domains reflect complex and overlapping forms of professional knowledge, a point emphasized in prior AI-TPACK frameworks (e.g., Celik, 2023; Chiu, 2025b; Sadaf et al., 2025). Research examining AI use in classrooms has further shown that teachers' competencies are expressed through coordinated decision-making across planning, enactment, and reflection that are determined by the content they are teaching, rather than through isolated instances of tool use (Wang et al., 2025). With that in mind, rather than operating independently, AI competencies for teaching are best understood as dynamically intersecting knowledge, skills, and dispositions that collectively support effective instructional practices that involve AI.

We propose these competency domains not to introduce an entirely new framework of AI competencies for teaching, but to show how competencies emphasized across existing frameworks can be inferred from teachers' choices and behaviors in instructional contexts. To do so, we return to the three overlapping roles of AI previously introduced: AI as a tool, as instructional content, and as part of the broader teaching context. Each role foregrounds different instructional demands and, in turn, makes different aspects of AI competence visible. Considering these roles allows us to examine how the common themes described in Part 2 could also be enacted in practice.

The six competency domains are shown in Figure 2 and described in the paragraphs that follow. The organization of domains is intended to show coordination across interrelated areas of practice rather than a suggested sequence or relative priority among domains. We further emphasize that these six competency domains are meant to provide a minimum structure for organizing recurring patterns of interaction with AI and for examining how AI competencies for teaching may be evidenced across planning, instruction, and reflection in varied instructional settings. These six domains include AI content knowledge and skills (AI-C), AI technological knowledge and skills (AI-T), AI pedagogical knowledge and skills (AI-P), ethical awareness of AI (AI-E), professional judgment and agency (AI-A), and openness to continuous learning (AI-L).

Figure 2. Domains of AI Competencies for Teaching



- **AI content knowledge and skills (AI-C) refer** to teachers' understanding of core AI concepts, representations, and societal implications, and their ability to translate that understanding into age-appropriate instruction. This domain includes knowing how AI systems are trained, what kinds of problems they are suited to address, and how AI concepts intersect with disciplinary content, as well as being able to design learning activities in which students examine AI outputs, limitations, bias, and real-world consequences. Frameworks reviewed in Part 2 consistently emphasize that teachers must be able to teach about AI in ways that foreground epistemic limits and social impact (aiEDU, 2025; Celik, 2023; Chiu, 2025b; Miao & Čukurova, 2024).
- **AI technological knowledge and skills (AI-T)** encompass teachers' functional understanding of how AI systems operate and their ability to interact with, interpret, and evaluate AI outputs in practice. Beyond general digital literacy, this domain includes skills such as formulating and refining prompts, recognizing hallucinations or bias, interpreting

system signals and variability, and diagnosing why AI outputs may differ across tools or contexts. These competencies are necessary for teachers to make informed decisions about when, how, and whether to use AI tools in instructional settings (Celik, 2023).

- **AI pedagogical knowledge and skills (AI-P)** involve teachers' capacity to integrate AI into curriculum, instruction, and assessment in ways that align with disciplinary goals and sound pedagogy, and to enact those plans responsively in classroom practice. This includes redesigning tasks in light of AI affordances, orchestrating human–AI roles during learning activities and making in-the-moment decisions about when to rely on, adapt, or override AI support to sustain students' cognitive and metacognitive engagement. Consistent with AI-TPACK (Chiu, 2025b) and the aiEDU AI Readiness Framework (aiEDU, 2025), AI use in this domain is anchored in pedagogical intent rather than novelty or efficiency alone.
- **Ethical awareness of AI (AI-E)** refers to teachers' ability to recognize, anticipate, and respond to ethical, equity, privacy, and safety issues associated with AI use in education. This includes evaluating AI systems for fairness, transparency, accountability, and data protection, as well as establishing norms and communicating expectations to students, families, and colleagues. Recent frameworks position ethical AI competencies as a core dimension of responsible AI-integrated teaching rather than a peripheral consideration (aiEDU, 2025; Celik, 2023; Miao & Čukurova, 2024). Teachers may enact ethical reasoning by making fairness, privacy, and transparency explicit in daily routines.
- **Professional judgment and agency (AI-A)** capture teachers' sense of authority and responsibility to make informed instructional decisions about AI use, including whether, when, and how AI should be incorporated, or deliberately excluded, in students' best interests. This domain is expressed through teachers' willingness to question AI recommendations, resist default tool behaviors, and advocate for changes that extend beyond their own classrooms (Kelley & Wenzel, 2025; Miao & Čukurova, 2024). Studies of AI-supported teaching further indicate that instructional impact depends critically on how teachers interpret, adapt, and sometimes override AI outputs, underscoring the need to consider how and when teachers apply professional judgment (Demszky et al., 2025; Lee & Song, 2024). Uncritical use of AI-generated explanations could obscure

misconceptions or oversimplify complex ideas (Bauer et al., 2025), reinforcing the importance of teachers' professional judgment in monitoring, adapting, or rejecting AI support in service of student learning.

- **Openness to continuous learning (AI-L)** reflects teachers' habits of reflection, experimentation, and self-directed professional learning that enable them to adapt to rapidly evolving AI tools, norms, and policies. Because AI systems change frequently in capability and impact, this domain emphasizes ongoing inquiry and revision of teaching practice rather than mastery of a fixed set of skills (aiEDU, 2025; Kelley & Wenzel, 2025).

As noted previously, these six domains are meant to reflect a coherent competency structure where strength lies in their intersections rather than their isolation. One perspective on these interconnections is implied by Figure 2, where AI-C, AI-T, and AI-P may be understood as a closely related core, with AI-E, AI-A, and AI-L operating across and around that core. In this way, AI-C provides conceptual grounding for what is instructionally necessary to know about AI, AI-T supports teachers in engaging AI systems and interpreting their outputs, and AI-P translates both into instructional design and enactment. At the same time, AI-E ensures that decisions across these domains remain oriented toward fairness, transparency, privacy, and student well-being; AI-A positions teachers as the ones who decide whether, when, and how AI should be used in light of pedagogical goals and contextual constraints; and AI-L supports the ongoing refinement of all domains as tools, norms, and educational expectations evolve. These connections among the competency domains should be treated as tentative for now and tested through further empirical work.

AI Competencies for Teaching Through the Lens of High-Leverage Teaching Practices

In instructional contexts, effective AI competencies for teaching become visible through teachers' use of high-leverage practices. High-leverage teaching practices (HLPs) refer to a set of instructional practices shown to be central to effective teaching across subjects, contexts, and grade levels (Ball & Forzani, 2011; Grossman et al., 2009; Phelps et al., in press; Sykes & Wilson, 2015). Rather than treating AI competencies for teaching as discrete skills or behaviors, we conceptualize them as connecting to HLPs when AI is present. From this perspective, AI competencies for teaching are not enacted as discrete technical skills, but as situated professional judgments that shape how teachers plan, enact, and adapt instruction when AI is present in various roles.

Anchoring AI competencies in HLPs provides a principled way to examine how these competencies are expressed in everyday instructional work. The eight HLPs described below represent key instructional practices through which teachers' interactions with AI could surface AI competencies for teaching. Table 1 summarizes how these eight HLPs serve as spaces in which observable evidence can be generated to illustrate AI competencies for teaching.

Drawing on students' cultural, family, intellectual, and personal experiences and resources. In this practice, teachers connect instruction to students' backgrounds and "funds of knowledge" (Gay, 2010; Ladson-Billings, 2014). When AI tools are involved, teachers attend to whether AI-generated materials reflect students' diverse cultural and linguistic experiences or risk perpetuating bias or stereotypes (Oyetade et al., 2025). For example, a teacher may review an AI-suggested reading passage for cultural bias or exclusionary language and adapt it to better resonate with students' communities (AI-E). By examining and modifying AI outputs, teachers exercise professional judgment to override or adjust AI suggestions so that materials engage and empower all learners (AI-A).

Mastering lesson content for instructional purposes. This practice involves deep engagement with subject matter, including anticipating student difficulties, clarifying key concepts, and maintaining alignment with learning goals. When AI is used in planning or instruction, teachers should vet and refine AI-generated content for accuracy and pedagogical soundness. For example, a teacher who uses an AI-generated simulation checks that it correctly represents underlying disciplinary principles and is appropriate for the instructional context (AI-T, AI-P, AI-C). Such verification ensures that AI supports subject-matter understanding and does not introduce misconceptions (Karaman & Göksu, 2024).

Selecting and designing instructional tasks, activity structures, and formats. Skilled teachers select or design tasks that are appropriately challenging, engaging, and aligned with instructional goals. In AI-mediated environments, this practice requires deliberate decisions about whether and how AI-based tasks should be incorporated. Teachers align AI use with pedagogical intent, adopting AI tools only when they meaningfully support learning goals and maintain rigor and equity in student thinking (AI-T, AI-P, AI-A). In doing so, teachers exercise professional judgment to better ensure that AI enhances rich learning opportunities (Zou et al., 2025).

Table 1. Examples of High-Leverage Teaching Practices as Sites for Evidencing AI Competencies for Teaching

High-leverage teaching practice	Examples of observable behaviors demonstrating AI competencies for teaching
Drawing on students' cultural, family, intellectual, and personal experiences and resources	• Reviews AI-generated materials for bias or cultural misalignment • Adapts or rejects AI outputs that conflict with students' lived experiences • Exercises professional authority over AI outputs to ensure equity and inclusion
Mastering lesson content for instructional purposes	• Verifies accuracy and conceptual integrity of AI-generated explanations or examples • Anticipates where AI may oversimplify or distort content • Integrates AI outputs only after aligning with lesson goals
Selecting / designing instructional tasks, activity structures, and formats	• Evaluates whether AI-supported tasks advance instructional intent • Uses AI selectively to support rigor and differentiation • Resists default AI recommendations that misalign with students' needs
Building a positive classroom climate	• Establishes norms for transparent, responsible AI use • Frames AI as a limited, fallible resource • Reinforces questioning of AI outputs and respectful human interaction
Enacting instructional tasks and activities	• Monitors AI-driven instructional supports in real time • Adjusts, pauses, or overrides AI pacing or prompts as needed • Uses professional judgment to sustain productive engagement
Engaging students with subject matter	• Uses AI to enrich content without outsourcing student thinking • Guides students in analyzing and interpreting AI-provided information • Intervenes when AI outputs are inaccurate or misleading
Orchestrating productive discourses	• Introduces AI-generated ideas as discussion artifacts, not authorities • Engages students in evaluating AI reasoning or assumptions • Positions AI as one perspective among many
Assessing and responding to student learning during instruction	• Interprets AI-generated analytics alongside observations and student work • Treats AI feedback as provisional evidence • Adjusts instruction based on integrated judgment

Note. The eight high-leverage teaching practices are drawn from Sykes & Wilson (2015) and based on a summary by Phelps et al. (in press).

Building a positive classroom climate. Teachers cultivate classrooms characterized by trust, inclusion, routines, and respectful engagement. In the presence of AI, this work extends to establishing clear norms for responsible and transparent AI use that support learning and academic integrity (Gouseti et al., 2025). For example, teachers may co-develop guidelines with students regarding appropriate uses of generative AI for assignments (Kelley & Wenzel, 2025). These classroom norms operate within, and often require interpretation of, broader school and district policies. Teachers play an important role in adapting those policies to instructional contexts and helping students understand both general norms and task-specific expectations. These practices reflect ethical awareness and professional agency in shaping classroom cultures where AI is used thoughtfully, fairly, and in service of learning (AI-E, AI-A, AI-C).

Enacting instructional tasks and activities. This practice concerns how teachers implement instruction in real time by introducing tasks, monitoring engagement, and adjusting pacing or support as needed. In AI-mediated lessons, teachers remain attentive to how AI tools shape students' activity and intervene when necessary (AI-T, AI-C, AI-P, AI-A). For instance, during a writing lesson supported by an AI-based grammar tool, a teacher may pause the system to clarify a misleading suggestion or prompt student reflection on recommended revisions. Such moment-to-moment decisions illustrate professional judgment in ensuring that AI functions as a support for learning.

Engaging students with subject matter. Teachers engage students in making sense of disciplinary content by connecting ideas to prior knowledge and responding to student thinking. When AI is involved, teachers decide when AI resources can enrich understanding and when human explanation or inquiry is more appropriate (AI-P, AI-C, AI-T). For example, a history teacher might use AI to generate multiple perspectives on a historical event and then guide students in evaluating their credibility, bias, and context. In this way, AI supports disciplinary reasoning rather than short-circuiting it by providing answers (Marzano et al., 2026).

Orchestrating productive discourses. Teachers create the conditions for classroom discussions that support respectful exchange, reasoning, and collective sense-making. With AI, teachers may introduce AI-generated solutions, arguments, or texts as objects of inquiry rather than authoritative answers (AI-C, AI-P, AI-A). For example, a teacher might ask students to evaluate the validity of an AI-generated solution and examine its assumptions. Treating AI outputs as discussable artifacts encourages critical thinking and analytical talk while reinforcing norms of evidence-based discourse (S. Choi et al., 2026).

Assessing and responding to student learning during instruction. This practice involves gathering informal evidence of student understanding and adjusting instruction in response. In AI-supported settings, teachers may draw on AI-generated analytics or alerts while interpreting them alongside observations, student work, and knowledge of learners (AI-T, AI-P, AI-C). Rather than following algorithmic recommendations uncritically, teachers evaluate whether AI feedback aligns with instructional goals and decide when to reteach, scaffold, or extend learning (E. Choi et al., 2025). In this way, AI serves as one source of evidence within a broader framework of professional judgment oriented toward students' best interests.

Illustrative Scenario: AI Competencies for Teaching in Practice

To show how AI competencies for teaching may be expressed in routine instructional work, we present a hypothetical scenario. This hypothetical scenario involves a vertically aligned middle school mathematics team integrating an AI-supported practice tool during a four-week unit on rational number operations. The purpose of the scenario is not to prescribe a model of AI use, but to surface observable instructional decisions, judgments, and artifacts through which the six proposed domains of AI competencies for teaching can be evidenced. Boxes 1 to 6 summarize the key aspects of AI competencies for teaching relevant to each component of the instructional scenario.

The Instructional Setting and Dilemma

Our illustrative scenario is set in a middle school serving approximately 400 students in Grades 6–8, with an average class size of 20–25 students per class. Students have 1:1 Chromebook access, and the curriculum is aligned with the Common Core State Standards (National Governors Association Center for Best Practices [NGA Center] & Council of Chief State School Officers [CCSSO], 2010) and approaches from Illustrative Mathematics (n.d.). Approximately 30% of students are English learners, and 15% have individualized education programs. Within this setting, a team of six mathematics teachers has formed to work across all three grade levels. They meet once every 2 weeks during lunch or after school to plan curriculum and discuss observations. During one meeting, the teacher team discusses patterns in student performance related to fractions and proportional reasoning across grades. Sixth-grade teachers note persistent procedural use of fraction division without conceptual understanding; seventh-grade teachers observe additive reasoning in proportional contexts; eighth-grade teachers trace errors in slope calculation back to weak fraction subtraction.

While meeting, a 7th grade teacher comments on the changes in how students are engaging with their homework in light of the availability of generative AI tools. Several members of the team note that they have observed patterns in homework performance that raise questions about student use of generative AI tools outside of class. Although some students are submitting very coherent-sounding answers to word problems, these answers are sometimes conceptually inaccurate, and the students cannot seem to explain their procedures for arriving at the answers provided. Meanwhile, other students are submitting less coherent-sounding answers that are more conceptually sound, and those students can explain their procedures. More than one teacher conveys that she suspects some students were using generative AI tools to complete assignments.

Furthermore, a new district initiative has catalyzed these discussions around AI and student learning. The initiative directly encourages teachers to integrate AI tools to support student learning in response to a new state-level policy related to AI in education. While the mandate sets broad expectations, teacher teams are expected to exercise professional agency in selecting and adapting school- and district- approved AI tools to align with their instructional goals.

Reflecting on the current mandate and the observation that these AI tools are likely already being used by students, in ways that appear uneven and potentially detrimental for students' learning, the teacher team agrees to explore the potential for using approved AI tools to support students' learning of grade-level concepts related to fractions and proportional reasoning. See Box 1.

Box 1. Features of AI Competencies for Teaching Relevant to Identifying the Instructional Dilemma

Evidence of AI competencies for teaching:

- **AI-P**: Teachers first articulate instructional goals (deep fraction understanding and coherent learning progressions), and then consider whether AI tools might support those goals. AI is framed as a potential support, not a driver of instruction.
- **AI-L:** Teachers collaboratively learn from each other and plan improvements.

Role of AI:

- **AI as tool** may not yet be enacted, but its potential role is defined by pedagogical needs.
- **AI as content** may not yet be evident but underlies teachers' knowledge that students need to develop awareness of how their use of AI tools has implications for their learning.
- **AI as context** may be present implicitly: concerns about generative AI use outside school influence the decisions to engage more directly with AI that facilitates students' awareness of its limitations.

How context shapes expression of key competencies for teaching:

- Because teachers work as a vertical team, competency is expressed through collective goal setting and shared interpretation of data, rather than through individual experimentation.

Evaluating and Selecting an AI Tool

Each teacher on the team researches AI-driven mathematics tools, focusing on adaptive tutoring and formative assessment platforms. They evaluate tools based on alignment with instructional goals, usability, cost, and ethical considerations. One promising tool is rejected after the technology coordinator identifies that it requires each student to individually log in using full names and personal email addresses, raising concerns about compliance with privacy policies.

The selected AI tool in use is a school-licensed adaptive practice platform with a teacher-facing dashboard and pseudonymous student identifiers. The adaptive platform's real-time dashboard creates frequent decision points that make teachers' interpretations of AI output visible. Even though the team members largely agree that the tool has potential promise in supporting students' learning, several teachers convey concern that they need to be attentive to issues surrounding equity, accessibility, and ethical judgment in how AI recommendations are taken up or overridden given their knowledge of the students they are serving. See Box 2.

Box 2. Features of AI Competencies for Teaching Relevant to Evaluating and Selecting the AI Tool

Evidence of AI competencies for teaching:

- **AI-T:** Teachers reason about how adaptive algorithms function and what kinds of inferences the system is likely to make about student performance.
- **AI-E:** Privacy, data minimization, and potential bias are treated as instructional considerations, not as compliance afterthoughts.
- **AI-A:** Teachers exercise authority to reject a tool despite its instructional appeal when ethical conditions are not met.

Role of AI:

- **AI as tool** may be examined prospectively, with attention to affordances and limits.
- **AI as content** may not be directly evident but sits under teachers' decisions about how well a specific tool aligns with instructional goals.
- **AI as context** may be visible in how district policy and privacy norms constrain acceptable use.

How context shapes expression of key competencies for teaching:

- The presence of a technology coordinator and district policies helps to inform and guide ethical reasoning observable through discissions about the potential affordances and risks of specific AI tools.

Planning Instructional Integration

After some deliberation among the team and the technology coordinator, they decide to use a school-approved AI platform that has features which appear promising in supporting students' learning of concepts related to fractions and proportional reasoning. The team then meets to design how the AI platform will be used during independent practice. Teachers plan to use the AI tool to differentiate fraction problems while they circulate and observe student reasoning. They prepare to adjust difficulty levels manually and draft explicit student guidelines, such as requiring students to attempt problems independently before requesting hints. Teachers also plan how AI-generated error patterns may be used to anchor whole-class discussions about the use of the AI tool. See Box 3.

Box 3. Features of AI Competencies for Teaching Relevant to Planning Instruction Involving the AI Tool

Evidence of AI competencies for teaching:

- **AI-P:** Teachers deliberately embed the AI tool within an existing instructional routine, rather than restructuring instruction around the tool.
- **AI-E:** Teachers recognize a need to create student guidelines that address responsible use and academic integrity.
- **AI-A:** Anticipated override points are identified in advance, signaling that AI recommendations are provisional.

Role of AI:

- **AI as tool** may be viewed as supporting differentiated practice.
- **AI as content** may appear indirectly as teachers plan to explain, at an age-appropriate level, how the system adapts.
- **AI as context** may shape norms for acceptable student behavior.

How context shapes expression of key competencies for teaching:

- The presence of an openly skeptical teacher on the team surfaces tensions around over-reliance, making norm-setting and negotiation key sites where competencies can be expressed.

Implementing Instruction Using the AI Tool in Class

During instruction, teachers introduce the AI tool by explaining to students how it adapts to problem difficulty based on student responses. As students work, teachers monitor the dashboard and make real-time decisions: increasing difficulty when students are not sufficiently challenged, pausing the system to provide human scaffolding, and intervening when students attempt to game the hint system. In one case, a teacher overrides an AI recommendation to lower difficulty after recognizing a student's valid visual strategy that the system failed to interpret correctly. See Box 4.

Box 4. Features of AI Competencies for Teaching Relevant to Implementing Instruction With the AI Tool

Evidence of AI competencies for teaching:

- **AI-P:** AI feedback is supplemented or replaced by teacher feedback when pedagogically necessary.
- **AI-T:** Teachers interpret dashboard signals as indicators requiring contextual explanation, not as direct diagnoses.
- **AI-A:** Teachers routinely override or adjust AI outputs.

Role of AI:

- **AI as tool** may function as a system that provides material for students to engage with while completing a learning task and provides information to teachers about student learning.
- **AI as conten**t may become more explicit when teachers use system behavior (e.g., hint pathways) as an object of discussion.
- **AI as context** may be made visible through the differences in how teachers interpret and make instructional decisions based on the outputs of the AI tool within their unique class environments.

How context shapes expression of key competencies for teaching:

- The adaptive dashboard creates frequent, visible decision points, creating situations where evidence of teacher processes for decision-making can be observed in action, rather than inferred from outcomes.

Using AI Outputs to Support Discourse

After students have an opportunity to engage with the AI platform, teachers use aggregated error patterns to select discussion prompts aligned with CCSS Mathematical Practice standards. Students analyze common misconceptions and compare AI-generated hint pathways, identifying where explanations were unclear or misleading. This positions students to critique AI feedback while deepening mathematical understanding. In some discussions, teachers also surface the possibility that students may use AI to question or "fact-check" explanations offered by the teacher. Rather than treating such moments only as challenges to authority, teachers frame them as opportunities for critical evaluation, comparison of evidence, and shared learning about why explanations from different humans and AI may provide different explanations on the same topic as a means to emphasize how students' comprehension and critical thinking are essential for an individual student to create meaning from information. See Box 5.

Box 5. Features of AI Competencies for Teaching Relevant to Supporting Students' Discourse Involving the AI Tool

Evidence of AI competencies for teaching:

- **AI-P:** Teachers repurpose AI analytics to support argumentation and sense-making.
- **AI-E:** Teachers manage discussion norms to avoid stigmatization.
- **AI-A:** Teachers discuss strategies to counter deference to AI authority.

Role of AI:

- **AI as tool** may be recognized in the use of the tool and its outputs as a topic for the whole class discussion.
- **AI as content** may be evident through the guided classroom discussions of AI-generated hint pathways.
- **AI as context** may be visible in how teachers frame AI feedback as one source of evidence among others, shaping classroom norms for authority, critique, and sense-making.

How context shapes expression of key competencies for teaching:

- The use of anonymized class-level data enables public discussion without singling out individual students, ideally supporting more equitable student participation.

Ongoing Reflection and Iteration

In subsequent team meetings, teachers review outcomes across grades. They identify differences in how students respond to AI supports and note equity concerns, including linguistic accessibility of the tool for English Learners. The team decides how to adjust hint settings, supplement AI explanations with visual support, and raise concerns with school leadership to ensure ongoing monitoring and safeguards. Box 6.

Box 6. Features of AI Competencies for Teaching Relevant to Supporting Teachers' Ongoing Reflection and Iteration Involving the AI Tool

Evidence of AI competencies for teaching:

- **AI-E:** Potential equity implications are discussed among teachers and specific types of decisions and actions are defined for situations that raise equity and accessibility concerns.
- **AI-A**: Teachers advocate for changes beyond their own classrooms.
- **AI-L:** Teachers treat AI integration as an iterative process informed by evidence.

Role of AI:

- **AI as tool** may be apparent in teachers' use of its outputs as evidence of student learning to guide instructional decisions.
- **AI as content** may be evident in teachers' creation of instructional materials that position AI-generated outputs as objects of student reflection.
- **AI as context** may be reflected in how the AI system becomes part of the instructional environment, which also necessitates coordination, monitoring, and accountability beyond individual classrooms.

How context shapes expression of key competencies for teaching:

- The vertical team structure enables cross-grade comparison, making differential impacts of AI visible and actionable.

Summary: From Identifying to Growing AI Competencies for Teaching

This scenario illustrates how AI competencies for teaching may be evidenced through instructional planning, in-the-moment decision-making, norm-setting around student AI use, and collaborative reflection. It also underscores that the expression of these competencies depends not only on what teachers know, but on the instructional conditions under which they work, and therefore may not be fully observable within any single activity or setting. Rather than appearing as discrete or self-contained behaviors, AI competencies for teaching are more likely to be inferred from patterns of decision-making and action across instructional scenarios. Recognizing this shifts attention from defining competencies in the abstract to considering how evidence of competencies can be responsibly interpreted in practice. Building on this enactment-focused account, the next section turns to implications for the design of assessments capable of capturing meaningful evidence across the six domains of AI competencies for teaching in ways that are context-sensitive.

Part 4: Tracing Teachers' Progress in Growing AI Competencies for Teaching

Recognizing that AI competencies for teaching can be evidenced through behaviors and decisions teachers make when AI is present, our focus now shifts to considering how such competencies grow and can be cultivated over time. A progress-oriented view of AI competencies emphasizes that teachers at different career stages may demonstrate competencies in different ways, and that expectations for growth should reflect a number of factors, including the instructional context, current expectations for the role of teaching, and the individual teacher's professional goals at a given time. This section examines how the six domains of AI competencies for teaching described in Part 3 may develop over time, considers implications for the design of valid and useful assessments of AI competencies for teaching, and explores how assessment evidence can be leveraged to support professional learning across the career continuum. We build on this previous section with the intent to address the third guiding question of this review (*How could evidence of AI competencies for teaching support teachers' professional growth?*), with a particular focus on how assessment could be designed to capture credible and situated evidence of AI competencies for teaching in ways that leverage complementary forms of evidence to support teachers' professional growth.

A Progress-Oriented View on AI Competencies for Teaching

Research on teacher expertise has long shown that growth is marked by qualitative shifts in how teachers perceive problems, coordinate multiple considerations, and exercise judgment, not by the accumulation of discrete skills (Berliner, 1988). Adopting such a progress-oriented view of AI competencies for teaching recognizes that they develop over time through experience, reflection, and changing contextual demands, rather than viewing them as a fixed set of behaviors that teachers either demonstrate or do not. Applying such a progress-oriented perspective helps guard against two possible misconceptions: treating early, tentative practice of a competency as deficient, and overlooking advanced applications of competencies that may be expressed through selective, infrequent, or principled non-use of AI.

Although a progress-oriented perspective remains largely theoretical and requires empirical validation, several existing frameworks already share the perspective that AI-related competencies for teaching unfold gradually as teachers encounter new demands and refine professional practice within teaching contexts (Kelley & Wenzel, 2025; Masla et al., 2025; Miao & Čukurova, 2024; Mikeladze et al., 2024; Prilop et al., 2025). This progress-oriented framing is also consistent with longstanding work on learning progressions, which emphasizes staged development of understanding and practice over time (Duncan & Rivet, 2013), and with recent initiatives that frame AI-related capacities as part of broader learner pathways within districts and systems (Mills et al., 2024). Any progression in AI competencies for teaching must ultimately be judged in relation to instructional effectiveness and student learning outcomes in a given context.

To support interpretation of evidence across a continuum of proficiency, we organize the developmental progression into three hypothetical levels: emerging, effective, and expert. Table 2 illustrates how the six competency domains described earlier may be expressed differently across these levels and how those expressions vary depending on whether AI is functioning as tool, content, or context. We emphasize that the goal in describing these hypothesized levels is to capture potential differences in patterns of decision-making and action. Given that the levels described here are hypothetical, we note that validation across diverse teaching contexts would be necessary before such progressions can be used as reliable benchmarks for assessment or professional learning design.

At the emerging level, teachers may be developing foundational capabilities for informed decision-making about when and how to use AI for teaching. Practices may be characterized by reliance on external guidance, preconfigured tools, or established routines. Teachers may primarily follow familiar procedures when leveraging AI tools and may engage AI mainly as a support for functional or administrative tasks. Engagement with AI as content or as context may be less consistent, particularly when these roles require conceptual explanation or ethical interpretation of AI in teaching contexts. There is some evidence to suggest that ethical awareness may develop more gradually than other AI competencies for teaching, as they depend on understanding both AI systems and the longer-term implications of such systems in specific educational settings (Ocak & Çaskurlu, 2025; Tagare et al., 2025). At this level, AI competencies for teaching may be evidenced through bounded professional judgment and agency, such as treating AI outputs as advisory and demonstrating judgment through principled non-use when AI is misaligned with instructional goals.

Table 2. **Hypothetical Progressions of AI Competencies for Teaching**

Competency domain	Emerging: Uses AI with guidance; follows established routines	Effective: Adapts and evaluates AI use to meet instructional goals	Expert: Leads principled AI integration; anticipates issues and mentors others
AI Content Knowledge and Skills (AI-C)	Identifies and names core AI concepts (e.g., data, models, training) using provided materials; selects examples that connect AI ideas to student-facing content.	Explains how AI systems produce outputs, including sources of error and bias; connects AI concepts to disciplinary content and addresses student questions about AI behavior.	Designs learning experiences in which students examine AI systems, their societal implications, and epistemic limits; transfers and adapts content across grade levels, disciplines, and audiences.
AI Technological Knowledge and Skills (AI-T)	Follows established procedures to operate AI tools; formulates prompts and observes outputs within defined tasks; notes when outputs differ from expectations.	Adjusts prompts based on output quality; compares outputs across conditions; identifies errors, hallucinations, or bias; selects tools based on task and learner demands.	Diagnoses patterns in system behavior across tools and contexts; anticipates failure modes before use; supports colleagues in evaluating and troubleshooting AI outputs.
AI Pedagogical Knowledge and Skills (AI-P)	Incorporates AI tools into existing lesson structures using pre-designed activities; positions AI as a resource within established instructional routines.	Redesigns tasks to use AI affordances in ways that sustain student cognitive engagement; makes deliberate decisions about when students interact with AI and when they work independently.	Designs learning environments in which AI use is integrated with disciplinary goals; adjusts instruction in real time based on student responses and AI-generated evidence.
Ethical Awareness of AI (AI-E)	Names ethical considerations (e.g., privacy, academic integrity) when prompted; references existing school or district policies when making decisions about AI use.	Evaluates AI tools and tasks for fairness, transparency, and student impact; establishes classroom norms for AI use and articulates the reasoning behind those norms to students.	Identifies ethical implications of AI use before they arise across varied instructional contexts; participates in school or district discussions on AI policy, equity, and accountability.
Professional Judgment and Agency (AI-A)	Considers AI-generated recommendations alongside other sources of information; makes decisions about AI use within the scope of individual lessons or tasks.	Evaluates whether, when, and how to use AI as a routine part of instructional planning; overrides or excludes AI tools when their outputs conflict with learning goals or student needs.	Establishes expectations for AI use that extend beyond individual classrooms; mentors colleagues in AI-related decision-making; advocates for policy changes at the school or district level.
Openness to Continuous Learning (AI-L)	Participates in structured professional learning on and with AI; tries new tools in defined contexts; records or discusses observations about how AI use affects instruction.	Reflects on outcomes of AI use across lessons; seeks peer feedback and targeted learning to address identified gaps; revises practice based on evidence from classroom experience.	Conducts sustained inquiry into AI use in teaching; contributes to professional learning communities, curriculum design, or knowledge-sharing efforts focused on AI in education.

Note. Stage labels (emerging, effective, expert) incorporate logic based on UNESCO's Acquire–Deepen–Create hypothesized progression for educators (Miao & Čukurova, 2024) and the Foundational and Applied AI Awareness–AI Application in Teaching and Learning–Strategic AI Leadership in Higher Education progression for higher education faculty (DEC, 2025). Stages represent a developmental continuum rather than discrete categories; teachers may demonstrate different levels across domains simultaneously. Competency domain definitions are provided in Part 3.

At the effective level, teachers may increasingly adjust and adapt AI tool use based on task demands and learner needs. AI tools may be selected and modified in response to output quality, and teachers may intervene when system behavior conflicts with instructional intent. AI concepts may be integrated into instruction as objects of student explanation or reflection, indicating a growing proficiency in connecting technical understanding to subject-area learning (Celik, 2023; Chiu, 2025b). Teachers may also articulate and enforce classroom norms for responsible AI use. A defining feature at this level may be more consistent coordination across competency domains, with content knowledge, technical understanding, pedagogical reasoning, and ethical considerations working together in instructional decision-making.

At the expert level, teachers may demonstrate flexible, context-sensitive judgment across AI's roles as tool, content, and context, and may further contribute to shaping AI-related practices beyond their own classrooms. This may include designing learning experiences in which students critically examine AI systems and their implications, anticipating limitations across contexts, and supporting colleagues in evaluating AI use. Teachers at this level may participate in school- or district-level discussions related to policy, equity, and accountability. Consistent with human-centered views of design for education (Hanington, 2010), advanced AI competencies for teaching are not presumed to be reflected in more frequent AI tool use, but rather in an expanded capacity to judge when AI tool use serves student learning, and to demonstrate agency in acting on that judgment in ways that may influence practice across classrooms, teams, or systems.

With these hypothetical levels in mind, we emphasize that progress is not likely to be synchronous across all competency domains. Some empirical evidence has shown that AI competencies are rarely evenly distributed within individual teachers; rather, levels of confidence, knowledge, and ethical reasoning related to AI varies quite a bit between and within teachers, even among pre-service teachers (Guan et al., 2025; Wijaya et al., 2024). We also emphasize that across these hypothetical levels, progress may be driven less by the accumulation of discrete knowledge and skills but more by changes in how teachers coordinate their knowledge, skills, dispositions, and contextual considerations when making instructional decisions involving AI. This perspective also aligns with broader theories of teacher expertise which emphasize shifts in problem representation, conditional reasoning, and the ability to balance competing goals under uncertainty as teachers advance in developing their expertise (Berliner, 2001).

Approaches to Assessing AI Competencies for Teaching

Viewed through a progress-oriented lens, AI competencies for teaching may be best understood as learnable and mutually reinforcing, with teachers demonstrating varying levels of proficiency across domains as these competencies develop through experience and context-specific practice. This perspective also has direct implications for assessment. First, progress-oriented views of AI competencies for teaching may help clarify guiding expectations that affect decisions about entry into the profession. For example, such a view can articulate what teachers new to the profession might reasonably be expected to demonstrate, while also indicating how those competencies may deepen, expand, or become more integrated as teachers gain experience. From this standpoint, teacher education programs and licensing systems may set foundational benchmarks while recognizing growth potential among teacher candidates, instead of expecting proficiency across all competency domains from the outset. Second, a progress-oriented view encourages meeting teachers where they are and identifying strategies for targeted and effective professional learning. This approach may also help recognize that, at every level, teachers bring assets and knowledge they can draw on to support their own continuous learning.

Within this context, documenting growth and mastery in AI competencies for teaching depends on assessment approaches that are both authentic to instructional work and interpretable across varying levels of proficiency in each competency domain. Evidence-centered design (ECD) offers one principled approach by articulating explicit claims about what teachers know and can do, identifying the kinds of evidence that would demonstrate those competencies, and then designing tasks and contexts that elicit that evidence in observable, authentic ways (Mislevy et al., 2003). Applied to AI competencies for teaching, ECD would require specifying, for each competency domain and developmental level, what a teacher would need to say, do, or produce to warrant an inference about their competence, as well as what assessment tasks would make that evidence visible.

Various assessment approaches can be understood as potential sources of ECD-aligned evidence, each capturing different facets of AI competencies for teaching. Some of these example types of assessment approaches include those listed below. Table 3 also summarizes typical evidence sources and their relative strengths and limitations with respect to each approach.

- **Self-report surveys and interviews** represent one approach for indirect assessment. For example, a self-report measure of AI competencies for teaching may ask teachers to rate their confidence in AI-related skills or frequency of tool use. Instruments such as the Artificial Intelligence Literacy Scale for Teachers (AILST; Ning et al., 2025) can surface perceived readiness, self-identified gaps, and professional learning needs, and are often most informative at the emerging stage. Self-report assessments have also been valuable for documenting teachers' concerns and aspirations, including widespread anxiety about keeping up with the rapid pace of AI development (Younis, 2025a, 2025b) and shifting perceptions of generative AI's role in instructional work (An & James, 2025; Kaplan-Rakowski et al., 2023). However, self-perception does not always correspond to enacted practice, and surveys offer only a partial proxy for more objective types of evidence of competencies.

- **Knowledge tests** provide a more objective measure of discrete knowledge components, including both factual knowledge items and scenario- or vignette-based reasoning tasks about AI systems. Ding et al. (2024), for example, developed an AI competency assessment for teachers composed of factual and scenario-based questions, such as identifying the meaning of "machine learning" or interpreting the output of an AI system in a classroom-relevant situation. These assessments can provide a more objective measure of discrete knowledge components, including distinctions among, as well as limitations and ideal uses of, different types of AI systems, such as recommender systems and LLMs (Kasneci et al., 2023). Complementary work has also operationalized teacher AI literacy or AI-TPACK constructs through validated instruments, offering additional models for measuring teacher knowledge and related competencies at scale (Setiyawan et al., 2025; Zhao et al., 2022). Such assessments, however, may not be suitable for capturing teachers' application of competencies in instructional settings.
- **Performance tasks and simulations** move closer to performance-based evidence by asking teachers to engage in scenarios that replicate some aspects of classroom instruction. For example, these types of tasks may require designing an AI-integrated lesson or responding to a classroom situation involving generative AI use (Meegan & Young, 2025; Mikeska et al., 2025a, 2025b). Such tasks can elicit integrated skills and real-time decision-making and are particularly useful for capturing coordination across competency domains that characterize experienced practice. They can also be paired with AI-enabled

supports that scaffold instructional work while preserving teacher oversight, providing additional opportunities to study and assess teacher–AI interaction in authentic settings (Seufert et al., 2025; Wang et al., 2025). At the same time, such types of assessments have historically been viewed as time- and resource-intensive to implement and score given the need for clear rubrics and well-trained raters to extract evidence of competencies.

- **Classroom observations, portfolios, and other teaching artifact-based approaches**, which may involve compiling lesson plans, student work samples, video recordings, and accompanying reflections, are yet another approach. These can be revealing of applied adaptive decision-making in context, where accumulated evidence across multiple occasions can also be examined. Without systematic observation protocols, however, it can be difficult to determine whether a single artifact reflects a broader pattern of competence (Meegan & Young, 2025).

Design Principles for Assessing AI Competencies for Teaching

The usefulness of various assessment approaches in measuring AI competencies for teaching depends not only on the format of assessment but also on the purpose of the assessment (e.g., which competencies, for whom, and for what) as well as the principles guiding its design. As noted previously, ECD provides a unifying framework by emphasizing explicit alignment among three components: competency claims, observable evidence, and assessment task design and administration. For example, surveys and tests may illuminate a teacher's AI-C or AI-E, whereas performance tasks and portfolios may better capture AI-P or AI-A.

On their own, no single approach for assessment is likely to be sufficient in capturing evidence across all domains of AI competencies for teaching (Tuomi, 2025). An emerging recommendation is to combine multiple sources of evidence into multifaceted assessment systems (Chiu & Sanusi, 2024; E. Choi et al., 2025; Zhou et al., 2025). Assessment systems of AI competencies for teaching that involve multiple assessment formats are most defensible when each source of evidence is explicitly linked to the claims based on the operationalization of a competency domain and expected progress levels, a key feature of ECD-aligned assessment approaches. With this in mind, we view the assessment approaches previously described as potentially complementary rather than competing. Applying ECD may also help ensure that assessments of AI competencies remain authentic, equitable, and developmentally meaningful.

Table 3. Approaches to Assessing Teachers' AI Competencies, With Descriptions, Strengths, and Limitations

Assessment type	Description	Strengths	Limitations
Self-report surveys and interviews	Teachers complete questionnaires or respond to interview questions assessing their own AI knowledge, usage, and confidence.	• Can cover multiple dimensions (knowledge, skills, attitudes) in a single instrument. • Useful for identifying teachers' perceptions of their abilities and areas for growth.	• Subjective; teachers may overestimate or underestimate their abilities. • May not accurately reflect actual classroom practice.
Knowledge tests	Objective quizzes that assess factual understanding of AI concepts.	• Objective and easy to administer at scale. • Can identify specific misconceptions or gaps in understanding.	• Do not assess how teachers apply knowledge in practice. • May not capture pedagogical or ethical integration of AI.
Performance tasks and simulations	Teachers demonstrate skills through authentic tasks, such as designing AI-integrated lessons or responding to AI-generated student queries.	• Provide authentic evidence of practice and decision-making. • Capture complex, context-relevant competencies.	• Resource-intensive to implement and score. • Require well-defined rubrics and trained evaluators for reliability.
Classroom observations, portfolios, and other teaching artifact-based approaches:	Teachers submit lesson plans, student work samples, or schedule in-person observation or submit recordings of classroom teaching for review.	• Offer rich, concrete evidence of real-world teaching practices. • Allow for flexibility and contextual relevance.	• Time-consuming to compile and evaluate. • Comparability across classrooms may be difficult without standardized criteria.

This emphasis on evidence, validity, and actionable interpretation is consistent with broader calls to support educators in making research-informed decisions about AI tools and integrating evidence into professional learning and instructional improvement (Sowa et al., 2025). We recognize that at least five general principles may help to operationalize these three ECD components across assessment formats.

First, alignment with high-leverage teaching and instructional practices is essential. Performance tasks and simulations could be used for evaluating how teachers leverage AI tools for teaching in realistic classroom scenarios, offering insight into instructional judgment and decision-making. This addresses ECD's task and evidence components: performance tasks are designed to elicit observable evidence that is recognizable and meaningful within real instructional contexts. Second, multidimensional scoring may allow for more nuanced profiles across domains like technical knowledge, pedagogy, and ethics, enabling more targeted support. Articulating these domains in advance reflects ECD's emphasis on explicit competency claims. Third, dynamic and formative assessments can scaffold growth over time, turning evaluation into a learning process that reflects the iterative nature of developing AI competencies for teaching. From an ECD perspective, formative use requires revisiting all three components iteratively: refining claims as teacher knowledge grows, updating evidence criteria, and revising tasks to reflect new instructional realities. Fourth, assessments must be designed to be fair and relevant across the highly diverse contexts teachers work in. In terms of ECD principles, assessments and their uses must be constructed so that the evidence they elicit reflects competency, not differential access to resources or otherwise risks misalignment with the underlying construct.

Finally, assessment systems must also be continuously reviewed and refined to remain valid as AI tools and knowledge of HLPs evolve. Within an ECD framework, this means periodically revisiting all three components by updating competency claims to reflect new high-leverage practices, revising evidence criteria as understanding of expert AI teaching deepens, and refreshing tasks to incorporate emerging tools and contexts. Ongoing analysis of scoring patterns (e.g., inconsistent rater agreement, wide score variability, evidence of score or item invariance, etc.) signals when tasks, rubrics, or scoring models need revision (Kane, 2013; Messick, 1995; Zumbo, 2007). Research–practice partnerships can support this improvement (Penuel et al., 2015), ensuring assessments keep pace with emerging AI tools and pedagogical shifts. Modular assessment designs with components that are refreshed periodically could further offer a viable way to capture complex and process-oriented dimensions of AI competencies for teaching, such as those which tap into critical thinking (see Molerov et al., 2020). Ultimately, ECD-aligned assessment task design choices must be treated not as a one-time decision but as a living framework, revisited as rapidly as the technologies and instructional practices it aims to capture.

Summary: From Identifying Evidence of AI Competencies for Teaching to Sustaining Them

Evidence-based observations of teachers' AI competencies that are valid and reliable could inform thoughtful, developmentally aligned decision-making across assessment, certification, and in-service professional learning. Viewing AI competencies from a progress-oriented perspective helps clarify what teachers need at different levels, while varied assessment approaches may offer complementary forms of evidence to support growth. Even with the strongest competency frameworks and aligned assessment systems, broader systemic and organizational conditions are needed for teachers to succeed in acquiring foundational AI competencies for teaching and to continue advancing them as technologies and their uses evolve. In the next and final section, we briefly consider several system-level conditions relevant to supporting teachers in acquiring and growing AI competencies for teaching and consider how they shape possibilities for responsible, equitable, and scalable professional learning for teachers.

Part 5: Moving Forward with AI Competencies for Teaching

Throughout this paper, we have strived to address the central question *What do teachers need to know and be able to do when AI is present in teaching and learning?* We aimed to clarify the kinds of knowledge, skills, and dispositions that teachers require to navigate AI-integrated classrooms, and to propose how AI competencies for teaching can be observed and supported in real teaching contexts. As AI tools continue to shape student learning experiences and teachers' workflows, ensuring that educators are prepared for this reality is no longer optional. At the same time, teacher preparation must safeguard what matters most in education: human-centered pedagogy, including teachers' autonomy, ethical reasoning, and relational work that supports students' learning and development. In AI-mediated classrooms, teachers should remain the primary instructional decision-makers by guiding learning and maintaining a focus on instructional goals and students' well-being, even as they leverage AI to enhance learning (Kim & Kwon, 2023). Given this work hinges on teachers' judgment in action, moving from conceptual frameworks to enacted practice requires credible, practice-embedded ways to recognize and support teachers' competency growth that makes teachers' instructional decision-making visible when AI is present. As noted in Part 4, performance-based assessments and simulations can make this instructional decision-making more visible.

When teachers develop strong competencies for teaching, including AI competencies for teaching, they should be better positioned to make thoughtful choices about whether, when, and how AI is used in their classrooms. A well-prepared teaching workforce could leverage AI as an educational resource while keeping technology uses aligned with core principles of effective, ethical, and equitable pedagogical practices. Several core observations about *AI competencies for teaching* have emerged through this work:

- **Teaching in contexts where AI is present in various roles requires more than technical know-how.** Effective use of AI in education requires a set of coordinated competencies, drawing the pedagogical, content-related, technical aspects of involving AI in teaching, as well as ethical awareness, professional judgment, and a willingness to engage in continuous learning. Teachers need to understand how AI works and what it can (and cannot) do, know how to integrate AI tools into curricula in pedagogically sound ways, and have the confidence and ethical awareness to use AI responsibly.
- **AI competencies for teaching likely develop over time, through practice and reflection.** Like other complex teaching skills, AI competencies for teaching grow through authentic practice, feedback, and ongoing professional learning. Teachers need opportunities to experiment with AI in simulated and real classroom contexts, learn from both successes and mistakes, and deepen their expertise as technologies evolve.
- **AI competencies for teaching are enacted through decisions that vary with instructional goals, student needs, available tools, and institutional constraints.** As teachers encounter new technologies, the ways their knowledge and skills interact with how they integrate AI into teaching, address ethical considerations, and exercise professional judgment will also necessarily evolve. This means that present-day AI competencies for teaching may look different in the future. From this perspective, AI competencies for teaching are most meaningful when teachers carry the disposition toward continuous professional learning and are supported in adapting to new demands.
- **Present-day AI competencies for teaching may become less distinct from foundational competencies for teaching in the future.** As certain AI-driven technologies become commonplace in schools, well-prepared teachers will likely be better able to leverage AI to enhance student learning, while also mitigating potential harms such as algorithmic bias, privacy breaches, over-reliance on automation, or erosion of student skills.

These observations underscore that AI competencies for teaching are complex, developmental, and deeply embedded in professional judgment. However, recognizing the nature of these competencies is only a first step. The more difficult challenge lies in building an assessment-and-support system, which could span organizational, cultural, and policy conditions to enable these competencies to be learned, evidenced (e.g., through performance tasks and simulations), interpreted, and practiced over time. Without supportive system-level conditions, even well-articulated frameworks risk remaining aspirational rather than actionable. In practice, effective assessment-and-support systems that foster and support teachers in sustaining AI competencies for teaching will require coherence across standards and competency frameworks for teachers and teaching, professional learning opportunities, approved AI tools and governance, and aligned assessment systems that provide educators with actionable feedback.

What is ultimately at stake is not whether AI can be integrated into education systems, but whether education systems can support teachers in developing the competencies needed to attend to the learning and developmental needs of students in contemporary AI-mediated environments (Zuo et al., 2025). In AI-mediated learning environments, a well-prepared and highly skilled teacher remains the designer of learning experiences, the interpreter of AI-generated insights, and the ethical steward of students' learning (Aldemir et al., 2025; Holstein & Olsen, 2023). By leveraging AI competencies for teaching, teachers may better ensure that the use of AI in education remains aligned with the profession's core commitments to human dignity, critical thinking, and social responsibility (Ahmad et al., 2025; Tagare et al., 2025).

Looking ahead, we envision a future of AI-integrated education where teachers, supported by the right competencies and system conditions, can use AI in ways that enhance all students' understanding, all while modeling responsible and transparent technology use. Students in these classrooms will learn with AI and about AI, guided by teachers who help them become critical and ethical users of technology. Achieving that future will likely depend on building systems that support implementation, including practice-based learning opportunities and aligned assessment systems that help teachers develop, demonstrate, and refine AI competencies in context. In this future scenario, the very concept of AI competencies for teaching is likely to seem outdated as it simply refers to what is meant by high-leverage teaching in contemporary technology-rich environments. However, the journey to that point will require embracing AI thoughtfully in order to transform it from a disruptive force into an opportunity to elevate the conditions of the profession and improve student learning in both the near- and long-term.

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Appendix A: Glossary

Term	Definition
AI as content	Situations in which AI itself is the object of instruction. This includes teaching about AI concepts (e.g., data, algorithms, model behavior), AI applications, and the ethical and societal implications of AI, in developmentally and disciplinarily appropriate ways.
AI as context	The broader sociotechnical environment shaped by AI systems that influences teaching and learning, even when AI is not explicitly used as a tool or taught as content. This includes students' out-of-school AI use, algorithmically mediated information environments, institutional policies, and societal norms related to AI.
AI as tool	Situations in which AI systems are used to support teaching and learning activities, such as planning, feedback, assessment, differentiation, or student work. In this role, AI use is embedded within teachers' pedagogical decisions and subject to professional judgment and oversight.
AI competencies for teaching	The knowledge, skills, dispositions, and professional capacities teachers draw on to make informed, context-sensitive decisions about *whether, when, and how* AI should be used (or not used) in the work of teaching and related professional responsibilities. AI competencies for teaching emphasize application and judgment in authentic educational contexts, rather than general familiarity with AI alone.
AI literacy	Foundational knowledge, skills, and attitudes related to understanding how AI systems work, evaluating their outputs, and recognizing their ethical and societal implications. AI literacy is generally domain-general and may apply across everyday, civic, or professional contexts; it serves as an important foundation for, but is not equivalent to, AI competencies for teaching.
AI-integrated teaching	Human-centered instructional practice in which teachers intentionally incorporate AI—directly or indirectly—into instruction, assessment, or professional workflows to support student learning. AI-integrated teaching is treated in this paper as *evidence* or *enactment* of AI competencies for teaching, rather than as a synonym for the competencies themselves.
Continuous learning (with respect to AI)	An orientation toward ongoing reflection, adaptation, and professional growth in response to the rapidly evolving nature of AI tools, norms, and policies. Continuous learning is treated as a core component of AI competencies for teaching rather than a discrete outcome.
Enactment (of AI competencies)	The ways AI competencies for teaching become visible through teachers' actions, decisions, and instructional practices in specific contexts. Enactment emphasizes that competencies are inferred from patterns of practice rather than directly observed as isolated behaviors.
Ethical reasoning / ethical awareness (re: AI)	The ability to recognize and respond to ethical issues associated with AI use in education, including concerns related to fairness, bias, privacy, transparency, accountability, and student well-being. Ethical reasoning is treated as an integral component of AI competencies for teaching rather than a separate or optional skill.
Evidence of AI competencies for teaching	Observable indicators—such as instructional choices, explanations, responses to AI outputs, and boundary-setting practices—that suggest underlying AI-related knowledge, judgment, and dispositions. Evidence is understood as context-dependent and distributed over time.
High-leverage teaching practices (HLPs)	Core instructional practices that are central to effective teaching and student learning across contexts (e.g., eliciting student thinking, facilitating discussion,

	providing feedback). In this paper, HLPs provide a lens for examining how AI competencies may be enacted within familiar teaching routines.
Human-centered teaching	An orientation to teaching that prioritizes students' learning, agency, well-being, and development over technological efficiency or automation. In AI-integrated contexts, human-centered teaching positions AI as a support for, rather than a replacement of, teachers' professional judgment and relational work.
Professional agency	Teachers' sense of authority and responsibility to shape how AI is used in their practice, including the ability to adapt, override, resist, or reject AI systems and recommendations. Professional agency emphasizes teachers as decision-makers rather than passive implementers of technology.
Professional judgment (in AI contexts)	Teachers' capacity to interpret instructional situations, evaluate AI tools and outputs, and make informed decisions aligned with pedagogical goals, ethical considerations, and students' needs. Professional judgment includes deciding *not* to use AI when it is misaligned with instructional purposes.
Systems-level conditions / school community context	The policies, infrastructure, leadership practices, professional learning structures, and cultural norms that shape teachers' opportunities to develop and enact AI competencies. These conditions influence what AI-competent teaching looks like in practice and what forms of evidence are feasible.

Appendix B: Process for Literature Identification

To identify relevant literature, we conducted a review focused specifically on teacher competencies for working with or teaching about AI. The search process followed a structured and iterative approach designed to capture scholarship explicitly addressing what teachers need to know and be able to do when working with or teaching about AI. The primary search was conducted in Google Scholar beginning in October 2025. Because the purpose of the search was to identify literature on teacher, rather than student, competencies in AI for teaching, pedagogy, and professional development, articles focused solely on students' AI literacy or student-level competencies were excluded from this portion of the review.

The search began with a scan of peer-reviewed research using Google Scholar. This initial search was built around constructed keyword combinations designed to isolate literature on *teachers'* AI competencies while excluding the much larger body of work devoted to *students'* AI literacy and student-level competencies. As outlined in Table B1, search terms were organized into two primary clusters: teacher-focused terms (e.g., "teacher," "educator," "K–12") and AI-competency terms (e.g., "AI literacy," "AI competencies," "artificial intelligence"). These clusters were paired to generate search strings that targeted the intersection of AI and teaching practice.

As the search progressed, the initial keyword set expanded to include terminology commonly used in discussions of educator professional learning and instructional integration of AI, such as "professional development," "AI-Pedagogy," and "competency framework." These additional terms, also listed in Table B1, helped ensure that the search captured literature attending to how teachers learn to work with AI as part of their ongoing professional growth.

After the initial keyword-based search, the literature pool was further expanded through established scholarly discovery techniques (see Table B2). The first of these was backward citation chasing, in which the reference lists of key articles were reviewed to identify relevant earlier studies and conceptual frameworks. This was complemented by forward citation search, which helped identify more recent or emerging publications that cited core works identified in the first phase. A third major source of literature came from ongoing sourcing. As new AI frameworks, empirical studies, or theoretical contributions appeared, they were incorporated into the review.

Included articles also adhered to the criteria presented in Table B3, which delineates the conceptual boundaries of the review. Only works addressing teachers, such as studies describing educator knowledge and skill requirements, analyses of teacher-AI interactions, development or validation of teacher competency frameworks, or professional learning interventions, were retained. Articles focused exclusively on students' AI literacy or competencies were treated separately to maintain conceptual clarity and ensure that the found articles remained tightly focused on teacher-specific needs.

Table B1. Primary Search Terms Showing General Component of Search String

Component	Included search terms
Teacher-specific AI terms	"teacher*," "educator*," "teacher education", "pre-service", "in-service", "K–12 teacher*", "school teacher*"
AI literacy/ competency terms	"AI literacy", "AI competence*", "artificial intelligence", "AI"
Framework or professional development terms	"framework", "professional learning", "professional development", "teacher training"

Note. Search strings connected as follows: "teacher-specific ai terms" and "ai literacy/competency terms" AND "framework/professional development terms"

Table B2. Secondary Identification Methods

Identification method	Description
Backward citation chasing	• Examination of reference lists from key articles and frameworks to identify foundational works.
Forward citation chasing	• Incorporation of newer studies that cited core articles identified in early review phases.
Ongoing sourcing	• Additional relevant works surfaced through continuous project activity, including: o articles and frameworks mentioned or shared by colleagues, o documents identified during collaborative reviews, o updated versions of frameworks and online first publications.

Table B3. Primary Inclusion/Exclusion Criteria

Criteria	Description
Inclusion	• Studies defining or examining *teacher* competencies, skills, knowledge, or dispositions related to artificial intelligence. • Conceptual frameworks, empirical studies, design frameworks, progression models, or professional development programs focused on educators.
Exclusion	• Studies focused exclusively on students' AI literacy, student skills, or student-oriented competency frameworks.

Appendix C: Additional Content

Table C1. AI's Roles in Teaching

Role of AI in teaching	What this role makes visible in teaching	Examples of AI roles enacted through teaching
AI as Tool	How teachers exercise professional judgment when AI mediates instructional planning, enactment, feedback, or assessment	• Selecting AI tools based on instructional purpose rather than convenience or novelty. • Setting boundaries for appropriate and principled use, including deliberate non-use when AI does not serve learning goals. • Monitoring and validating AI outputs for accuracy, bias, and alignment with instructional aims. • Structuring learning activities so AI supports, rather than substitutes for, students' reasoning and sense-making. • Reinvesting efficiency gains from AI-supported productivity (e.g., drafting, planning) into high-leverage instructional practices such as diagnosing student thinking, supporting classroom discourse, or engaging in deeper professional reflection.
AI as Content	How teachers support students' understanding of AI systems as objects of learning, including their operation, limitations, and societal implications	• Explaining core AI concepts (e.g., data, algorithms, model behavior) in developmentally appropriate ways. • Connecting AI concepts to disciplinary content (e.g., recommendation systems in social studies, machine learning in computer science). • Eliciting and interpreting evidence of student understanding of AI-generated outputs and uncertainty. • Surfacing and addressing misconceptions about AI capabilities and limitations. • Engaging students in examining ethical issues such as bias, fairness, misinformation, and privacy embedded in AI systems, while also helping students understand both general principles and their local school policies for AI use.
AI as Context	How teachers respond to AI as a pervasive sociotechnical condition shaping norms, expectations, and governance of learning	• Establishing and communicating clear expectations for appropriate AI use across learning activities. • Requiring disclosure and reflection when students use AI in coursework. • Facilitating discussion about academic integrity, equity, and the potential for AI systems to reinforce bias or misinformation. • Interpreting and enacting evolving policies related to data privacy, transparency, and accountability. • Communicating transparently with students and families about AI use and modeling ongoing learning in response to new tools or guidance.

Table C2. Alignment of Common Themes (Part 2) and AI Competency Domains (Part 3)

Common theme in existing AI competency frameworks for teaching (Part 2)		Domains of AI competencies for teaching (Part 3)	
Common theme	Core idea	Aligned AI competency domains	Rationale for alignment with common theme
-	-	AI-C (AI Content Knowledge)	While not directly reflected in one of the themes, some frameworks (e.g., TPACK frameworks) recognize the importance of content knowledge. Teachers are ultimately expected to teach something and this domain reflects that conceptual grounding is essential for teachers to interpret AI behavior and make informed instructional decisions to support student learning.
1. Foundational understanding of AI as a prerequisite for informed use	Teachers need conceptual (not developer-level) understanding of how AI systems work, their limits, and risks	AI-T (AI Technological Knowledge)	Foundational understanding supports both instruction *about* AI and informed engagement *with* AI systems in practice. Knowledge of core AI concepts enables teachers to explain how AI works and to situate those ideas within disciplinary instruction, while technological understanding enables teachers to interpret, evaluate, and troubleshoot AI outputs when AI systems are used as instructional or professional tools.
2. Pedagogical integration that reinforces, rather than replaces, high-quality teaching	AI should augment instructional goals and disciplinary practice, not substitute for teaching	AI-P (AI Pedagogical Knowledge)	Pedagogical integration is reflected in teachers' capacity to align AI use with instructional goals, disciplinary norms, and students' learning needs. This includes redesigning tasks, orchestrating human–AI roles during instruction and making in-the-moment decisions that sustain cognitive engagement rather than deferring instructional judgment to AI systems.
3. Ethical and human-centered judgment as an integral dimension of competence	Ethical reasoning, equity, privacy, and student well-being are core, not optional, features of competent AI use	AI-E (Ethical Awareness of AI)	Ethical awareness is evident in teachers' ability to recognize and respond to issues of fairness, bias, privacy, transparency, and student well-being when AI is present. This includes anticipating potential harms, establishing norms for responsible use, and making ethical considerations explicit in instructional decisions and classroom routines.
4. Professional agency and confidence to	Teachers must retain authority to adopt, adapt, override, or reject AI systems	AI-A (Professional Judgment and Agency)	Professional agency is expressed through teachers' authority and responsibility to make principled decisions about AI use, including whether, when, and how AI should

exercise judgment over AI			be incorporated or deliberately excluded. Exercising judgment over AI systems positions teachers as accountable decision-makers rather than passive adopters of automated recommendations or default tool behaviors.
5. Continuous learning and adaptation in a rapidly evolving landscape	AI competencies are developmental and require ongoing reflection, experimentation, and learning	AI-L (Openness to Continuous Learning)	Openness to continuous learning captures the ongoing reflection, experimentation, and professional learning required to adapt practice as AI tools, norms, and policies evolve. Treating AI integration as an iterative design problem rather than a fixed solution supports sustained competency development over time.

Notes

[1] This framing builds on prior work by Prilop et al. (2025), who organize AI literacy around AI as teaching content, AI as a teaching tool, and AI as a learning tool, situated within broader ethical, cultural, social, political, and economic contexts. However, while Prilop et al. (2025) include AI as a learning tool in their triadic conceptualization, their empirical findings suggest that this dimension was only weakly articulated by teacher educators. In their qualitative analysis of perceived essential AI knowledge for pre-service teachers, references to AI as a learning tool, particularly attention to students' independent or unintended uses of generative AI, were rare compared to the dominant emphasis on AI as teaching content and AI as a teaching tool. Prilop et al. explicitly note that this perspective, though important, was not widely foregrounded and requires further research in teacher education. Responding to this finding, we reframe the third role more broadly as AI as context, a move that captures the largely implicit but underdeveloped recognition that AI increasingly functions as an ambient condition of learning environments. From this perspective, AI shapes how students encounter information, participate socially, and engage civically, regardless of whether AI is intentionally designed into instruction. Conceptualizing AI as context extends Prilop et al.'s framework by foregrounding the sociotechnical conditions within which teaching and learning now routinely occur and aligns with scholarship emphasizing the social, cultural, and civic dimensions of AI in education (Walsh et al., 2024; Yetisensoy & Rapoport, 2023).

[2] In this context, "observations" of teaching competencies refers to the systematic collection and interpretation of evidence assembled across a teacher's practice over time, including lesson designs, the use or deliberate non-use of AI tools, responses to AI-generated outputs, boundary-setting practices, student tasks, and collaborative planning artifacts, rather than to single classroom moments.

Suggested Citation:

Ober, T. M., Tenison, C., Phelps, G., Renfrow-Symon, E., Mikeska, J., & Dean, V. J. (2026). *AI competencies for teaching: From conceptual frameworks to enacted practices* (ETS Research Report Series No. RR-26-07). https://doi.org/10.64634/z5j3ts49

Action Editor: Jessie Sparks

Reviewers: Beata Beigman Klebanov and Tenaha O'Reilly

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