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Article

Rethinking Teacher AI Literacy in the Age of Generative AI: From Technical Competence to Human–AI Professional Agency

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Abstract: Generative AI is becoming embedded in lesson preparation, instructional design, assessment, feedback, and professional learning, shifting the question of teacher AI literacy from tool use to professional judgment. This conceptual commentary reviews the development of AI literacy and teacher AI literacy and focuses on four debates: general versus professional literacy, tool proficiency versus substantive literacy, technological augmentation versus professional judgment, and capability expansion versus professional deskilling. It reconceptualizes teacher AI literacy as an integrated professional capacity oriented toward educational purposes and bounded by ethical responsibility. A six-dimensional structure is proposed — understanding, applying, evaluating, regulating, collaborating, and taking responsibility — organized from basic technological understanding to professional judgment and human – AI agency. The article argues that mature teacher AI literacy is not indicated by greater dependence on AI, but by teachers' ability to decide when AI should be used, how its outputs should be verified and adapted, and where its participation should stop.

Keywords: artificial intelligence literacy; teacher AI literacy; generative artificial intelligence; professional judgment; teacher agency; human–AI collaboration

1. Introduction: From Using AI to Judging AI

Artificial intelligence did not enter education with generative AI. Earlier applications of AI in education focused largely on intelligent tutoring, learning analytics, automated assessment, personalized recommendation, and learning prediction. These systems were often highly encapsulated technologically, leaving teachers primarily as users, recipients, or indirect participants in AI-supported processes. Previous research has noted a long-standing imbalance in AI-in-education scholarship, in which technological systems have occupied a prominent position while the roles of educators, pedagogical theory, and educational values have received comparatively less attention (Zawacki-Richter et al., 2019). The rapid diffusion of generative AI has moved this long-standing concern from the research literature into everyday teaching practice.

Large language models represented by ChatGPT have changed the way AI enters teachers' work. Teachers no longer need advanced programming knowledge or prolonged software training to ask AI, through natural-language interaction, to generate lesson plans, cases, test items, assessment rubrics, learning materials, and feedback. Generative AI has therefore shifted from being a specialized technical system to an everyday tool that can directly participate in knowledge production, instructional design, and educational judgment. Its advantages are evident: it can reduce the cost of information retrieval and content generation, expand the range of instructional options and material variations available to teachers, and create new possibilities for personalized instruction, rapid feedback, and professional learning (Kasneci et al., 2023).

Yet ease of use does not imply ease of correct use. When AI presents content in fluent, complete, and seemingly authoritative language, factual errors, fabricated sources, implicit bias, and inappropriate recommendations may become more difficult to detect. If teachers master prompt techniques and content generation but cannot judge whether AI output is accurate, suitable for particular learners, aligned with curriculum goals, or likely to displace necessary learning processes, then high-level AI use competence cannot be equated with high-level AI literacy. In some circumstances, it may even amplify educational risk.

This shift changes the central question of teacher AI literacy. In the past, it was reasonable to ask, "Can teachers use AI?" Today, more important questions are: "Do teachers know when AI should be used, why it should be used, how its output should be verified, when it should be rejected, and who bears ultimate responsibility after AI participates in educational decision-making?" Long and Magerko (2020) defined AI literacy as a set of competencies that enable individuals to critically evaluate AI, communicate and collaborate effectively with AI,

and use AI across contexts. Ng et al. (2021) further summarized AI literacy in terms of knowing and understanding AI, using and applying AI, evaluating and creating AI, and AI ethics. These studies established a foundation for understanding AI literacy as more than technical operation.

However, general AI literacy does not fully capture the requirements of teaching as a profession. An ordinary user may only need to decide whether an AI-generated answer is useful. A teacher must additionally judge whether it has educational value, whether it matches learners' developmental levels and curriculum goals, whether it creates unnecessary cognitive substitution, and whether it alters the professional responsibilities that teachers are expected to carry. This article therefore argues that, in the age of generative AI, teacher AI literacy should be situated within the broader discussion of teacher professionalism. It should not be understood primarily as a set of tool-related knowledge and operational skills, but as an integrated professional capacity through which teachers maintain professional judgment, ethical responsibility, self-regulation, and educational agency when AI becomes deeply involved in educational work.

2. From AI Literacy to Teacher AI Literacy: Conceptual Development and Professionalization

2.1 AI Literacy: From Technical Understanding to Critical Engagement

The emergence of AI literacy fundamentally responds to the competencies required when AI moves from specialized technical domains into everyday life. Long and Magerko (2020) emphasized that AI literacy includes recognizing AI, understanding its capabilities and limitations, understanding machine learning and data, recognizing the human role in AI systems, and addressing ethical concerns. An important contribution of this formulation is that it does not reduce AI literacy to programming. Instead, it foregrounds understanding, judgment, and critique in human interaction with AI.

Ng et al. (2021) further emphasized the multidimensional nature of AI literacy, including knowing and understanding AI, using and applying AI, evaluating and creating AI, and AI ethics. Subsequent measurement studies have reflected the same broadening of focus. Wang et al. (2023) distinguished awareness, use, evaluation, and ethics; the SNAIL developed by Laupichler et al. (2023) highlighted technical understanding, critical appraisal, and practical application; and the MAILS proposed by Carolus et al. (2023) further incorporated AI self-efficacy, self-management, and meta-competencies. Collectively, these developments suggest that AI literacy research is shifting from the question of whether people can master

technology toward the question of how people can act autonomously, effectively, and responsibly in AI-mediated environments.

2.2 Teacher AI Literacy: General AI Literacy Embedded in Professional Practice

Teacher AI literacy has a clear historical continuity with teachers' digital competence. Frameworks such as DigCompEdu have already demonstrated that teachers' technological competence cannot be defined in the same way as ordinary users' operational competence; rather, it must be embedded in professional engagement, digital resources, teaching and learning, assessment, learner empowerment, and the development of learners' digital competence (Redecker, 2017). In the same way, once AI literacy enters the teaching profession, it necessarily undergoes professional reconstruction.

The distinctive feature of teaching is that technological decisions are inseparable from knowledge selection, learning processes, developmental judgment, assessment and feedback, and educational relationships. Ayanwale et al. (2022) found that teachers' readiness to teach AI is not determined by technical conditions alone, but is also shaped by confidence, perceived relevance, and attitudes. Velander et al. (2024) showed that teachers' understanding of AI is often formed through informal learning, and that incomplete or inaccurate conceptions can directly affect classroom implementation. From a TPACK perspective, Yue et al. (2024) likewise found clear gaps in teachers' AI-related content knowledge and technological knowledge.

More importantly, teacher AI literacy has expanded from "how to teach AI" to "how to use AI for education across subject areas." The former mainly requires teachers to understand AI concepts and explain them to students; the latter requires teachers to judge whether AI should enter curriculum design, task arrangement, feedback, assessment, and learning support. As generative AI becomes a general-purpose technology, this requirement is no longer confined to information technology teachers. It has become a professional issue shared by teachers across disciplines.

2.3 The Structural Shift Brought by Generative AI: Lower Barriers to Use, Higher Barriers to Judgment

One of the most consequential changes introduced by generative AI is the substantial reduction in operational barriers. Traditional technologies often become more demanding as complexity increases, requiring users to master more specialized operations. Generative AI

displays the opposite tendency: as model capabilities improve and natural-language interaction becomes more sophisticated, users need fewer explicit technical operations to complete complex tasks. This creates an important paradox: the easier AI becomes to use, the less appropriate it is to use "ability to operate AI" as the primary criterion for judging AI literacy.

One teacher may understand little about the probabilistic generation mechanisms of large language models, hallucination risks, or data boundaries, yet still generate complete lesson plans with great fluency. Another may use AI less frequently but accurately identify errors, know which student information should not be uploaded, and explain why a particular task should not be delegated to AI. If AI literacy is evaluated only through frequency of use, number of tools, or prompting proficiency, the first teacher may appear more literate. From the perspective of professional responsibility, however, the second may demonstrate more mature AI judgment. Generative AI therefore pushes teacher AI literacy from an operational capability toward a meta-level capability: teachers must not only be able to act, but also be able to judge whether they should act in that way.

3. Major Areas of Consensus in Current Research on Teacher AI Literacy

3.1 Basic Understanding as a Precondition for Professional Judgment

Teachers do not need to become AI engineers, but they do need a sufficiently accurate mental model of the technology to support professional decision-making. At a minimum, teachers should understand that generative AI outputs are probabilistic, that linguistic fluency does not guarantee factual accuracy, and that models may hallucinate, reproduce bias, or produce erroneous attributions. They also need a basic understanding of training data, privacy, and platform-use boundaries. Kasneci et al. (2023) argued that the educational use of large language models requires both teachers and learners to understand their capabilities and limitations and to develop mechanisms for fact-checking and critical thinking. The value of basic AI knowledge, therefore, lies not in accumulating terminology but in preventing educational decisions from being built on inaccurate assumptions about how the technology works.

3.2 AI Application Must Remain Subordinate to Pedagogical Goals

Teacher AI literacy cannot be reduced to whether a teacher can activate a particular function. The same AI capability may have very different educational implications depending on the learning goal and stage of instruction. Automatically generating ten texts at different

difficulty levels does not, by itself, constitute instructional innovation. Teachers must still judge whether those texts align with curriculum goals, match students' prior knowledge, display an appropriate progression of difficulty, and actually address an existing pedagogical problem. The UNESCO AI competency framework for teachers treats "AI pedagogy" as a distinct dimension, emphasizing that AI must be understood within the framework of pedagogy and educational purposes (Miao & Cukurova, 2024).

3.3 Evaluating AI Output Is More Important Than Generating AI Output

Generative AI lowers the cost of generation but substantially increases the importance of evaluation. When AI begins to propose learning objectives, analyze student errors, formulate assessment criteria, and generate intervention recommendations, teachers are no longer dealing only with automated execution. They are dealing with machine-generated judgments. Teachers therefore need the capacity to judge those judgments at a second order, including fact-checking, source scrutiny, logical evaluation, disciplinary accuracy, age appropriateness, and bias detection. A core competency in future teacher AI literacy may therefore be less prompt generation than verification and evaluation.

3.4 Ethics and Responsibility Are Not Add-On Dimensions but Boundary Conditions

AI use in education raises issues of privacy, data security, algorithmic bias, fairness, transparency, intellectual property, and accountability (Akgun & Greenhow, 2022). For teachers, these issues have direct professional consequences. Uploading student work to a public platform may create data risks; directly adopting AI-generated assessment may produce unfair outcomes; and using AI predictions to judge students' potential may create labeling effects. Ethics should therefore not be treated as an additional item appended at the end of an AI literacy framework, but as a boundary condition governing every act of AI use.

4. Four Core Debates in Research on Teacher AI Literacy

These debates emerge because the field has reached broad agreement on the need for technical understanding, pedagogical alignment, critical evaluation, and ethical awareness, yet has not fully resolved how these elements should be organized within teacher professionalism. The following four debates therefore focus on the conceptual boundaries and professional consequences of teacher AI literacy rather than on the mere presence of AI in teaching.

4.1 Is Teacher AI Literacy an Occupational Version of General AI Literacy or an Independent Professional Literacy?

A considerable portion of current research still follows a "general AI literacy plus educational context" logic: it first examines whether teachers understand AI, can use AI, and attend to ethical issues, and then adds several items on instructional application. This approach facilitates continuity with the broader AI literacy literature, but it may underestimate the professional specificity of teaching.

Teachers do not simply "use a few more educational AI tools" because of their occupation. Every AI-related decision made by a teacher is embedded in learning objectives, learner needs, curriculum norms, and educational responsibility. An ordinary user may treat usefulness as the primary criterion, whereas a teacher must also ask whether an AI-supported action has educational value, whether it changes a learning process that students should experience themselves, whether it is developmentally appropriate, and whether the teacher can responsibly stand behind the outcome. Teacher AI literacy should therefore be understood as a professionally embedded literacy. General AI literacy asks how people understand and use AI; teacher AI literacy asks how teachers select, constrain, verify, and use AI while fulfilling professional responsibilities.

4.2 Does Being Able to Use AI Mean Having High AI Literacy?

Frequency of AI use, tool proficiency, and prompt-writing skill are easy to observe and therefore easy to adopt as indicators of training success. Yet these variables show only that teachers use AI, not that they understand it or can use it responsibly. Teachers may use generative AI frequently while never checking facts, distinguishing task risks, scrutinizing bias, or recognizing which student data should not be uploaded. Under such conditions, technical fluency may amplify rather than reduce risk.

Wang et al. (2023) distinguished use, evaluation, and ethics, while Laupichler et al. (2023) treated critical appraisal as an independent dimension. These distinctions show that use is only one component of AI literacy. If a scale is dominated by items such as "I can use AI to generate lesson plans" or "I can use AI to make presentations," it may be measuring AI self-efficacy or AI use competence more than AI literacy in a substantive sense. Research on teacher AI literacy therefore needs to avoid replacing literacy with the proxy assumption that "more use means higher literacy."

4.3 Is the Core of Teacher AI Literacy Technological Augmentation or Professional Judgment?

Generative AI is often described as a tool for augmenting teacher capability. AI can indeed reduce repetitive work, broaden the range of available options, and improve information-processing efficiency. Yet many educational tasks cannot be judged by efficiency alone. Whether students should struggle with a problem independently, whether feedback should be immediate, and whether an error should be corrected or preserved as an opportunity for inquiry are matters of professional judgment. AI can generate an answer, but it cannot automatically decide whether that answer should be given at this particular moment.

Accordingly, the more capable AI becomes, the importance of teachers' professional judgment does not diminish; it increases. When technology is weak, teachers must personally execute tasks. As technology becomes more capable, teachers' work increasingly shifts toward defining tasks, allocating tasks, monitoring processes, and judging results. The center of teacher AI literacy should therefore move beyond technical competence toward professional judgment. Mature teacher AI literacy does not mean "using whatever AI can do"; it means making educational purposes the higher-order criterion for deciding whether AI should enter a task at all.

4.4 Is AI an Extender of Professional Capability or a Trigger for Professional Deskilling?

Reducing teachers' workload does not necessarily mean promoting their professional development. Research on automation has long shown that human–automation relationships can involve appropriate use, but also misuse, overreliance, and reduced monitoring (Parasuraman & Riley, 1997). The same risk exists in teachers' work. If teachers routinely ask AI to generate learning objectives, diagnose student errors, write feedback, design assessment rubrics, and formulate improvement plans, work may become more efficient, but whether teachers' own professional reasoning continues to develop becomes an important question.

A distinction is therefore needed between capability-extending use and capability-substituting use. In the first, AI provides information, options, and computational support while teachers continue to compare, judge, revise, and reflect. In the second, cognitive tasks that have professional learning value are directly outsourced to AI, reducing teachers' own analysis and decision-making. The former may support professional augmentation; the latter may contribute to professional deskilling. Teacher AI literacy must therefore include not only

the ability to use AI, but also AI self-regulation and the maintenance of professional agency in AI-rich environments. Priestley et al. (2015) remind us that teacher professionalism is not simply a matter of possessing capabilities, but also of being able to act autonomously in context on the basis of values, purposes, and environmental conditions. Generative AI makes this agency impossible to ignore within any serious framework of teacher AI literacy.

5. Reconceptualizing Teacher AI Literacy in the Age of Generative AI

5.1 Conceptual Premise: Teacher AI Literacy as a System of Professional Judgment

Reconceptualizing teacher AI literacy first requires a change in the unit of analysis. If the unit of analysis is the tool, the relevant questions become whether teachers can use a platform, write prompts, or generate materials. If the unit of analysis is the professional task, the questions become whether teachers can correctly define the role of AI in lesson preparation, instruction, assessment, feedback, and professional learning. This article argues that the latter better reflects the actual transformation of teachers' work in the age of generative AI.

Teacher AI literacy should therefore not be understood as a simple sum of independent skills. It is better understood as a system of judgment organized around professional educational tasks. At minimum, this system performs five sequential judgments. First, the teacher identifies the goals and risks of the educational task. Second, the teacher judges whether AI is appropriate for participation. Third, once AI participates, the teacher verifies its output. Fourth, the teacher translates valid output into pedagogical action suited to learners and context. Fifth, the teacher assumes responsibility for the final action and its consequences. Technical knowledge, prompting skill, and platform operation are resources within this judgment system, not the system itself.

This perspective explains why "being able to use AI" is not equivalent to "possessing high AI literacy." High-level teacher AI literacy must be expressed in the continuous coordination of technological capability, educational purpose, and ethical boundaries. What AI can do is a technical question; whether AI should do it is a question of educational judgment; and who is responsible after AI participates is a question of professional ethics. None of these three questions can be omitted.

5.2 Core Definition: From Tool Competence to Integrated Professional Agency

On the basis of the preceding analysis, this article defines teacher AI literacy as the integrated professional capacity through which teachers, grounded in an understanding of the

basic mechanisms, capabilities, and limitations of AI, make appropriate choices about AI, apply it effectively, evaluate it critically, and regulate it continuously in accordance with educational purposes, learner needs, and professional ethics, while maintaining professional judgment, human agency, and ultimate responsibility in human–AI educational practice.

This definition involves four important shifts. First, it moves from AI use to AI governance. Teachers need not only to know how to invoke AI, but also to set the scope, conditions, and exit mechanisms of AI participation. Second, it moves from general competence to professional embeddedness. AI capabilities acquire educational meaning only when situated within curriculum goals, disciplinary knowledge, learner development, and classroom relationships. Third, it moves from task efficiency to educational value. Greater efficiency does not automatically mean better educational quality; teachers must judge whether efficiency gains come at the cost of weakening learning processes, professional judgment, or learner agency. Fourth, it moves from human–AI division of labor to a structure of human–AI responsibility. AI may undertake information processing, generation, and comparison, but educational purposes, consequential judgments, and ultimate responsibility cannot be unconditionally transferred to the system.

The standard of mature teacher AI literacy is therefore not "how much work AI completes," but whether the teacher can design and sustain a human–AI relationship that is explainable, verifiable, adjustable, and ultimately accountable to the teacher. In this sense, human–AI professional agency is not an additional seventh skill; it is the overarching orientation of the entire teacher AI literacy structure.

5.3 A Six-Dimensional Structure: Understanding, Applying, Evaluating, Regulating, Collaborating, and Taking Responsibility

5.3.1 Understanding AI

Understanding AI is the cognitive foundation of sound professional judgment. It includes basic knowledge of AI principles, training data, generative mechanisms, probabilistic output, hallucination, bias, and system boundaries. The aim is not to require teachers to master algorithmic derivations, but to develop a sufficiently accurate mental model of the technology so that they can anticipate which tasks AI may handle effectively and in which situations it is more likely to fail.

More importantly, understanding AI must include awareness of capability boundaries. Teachers need to know not only what AI can do, but also what it does not know and cannot

guarantee. A large language model may generate apparently complete references, but this does not make it a reliable bibliographic database. It may produce a polished evaluation of a student, but that does not mean it understands the student's developmental history. The central question is: Do I understand why this system may produce this result, and why fluency alone is insufficient grounds for trust?

5.3.2 Applying AI

Applying AI refers to teachers' ability to select appropriate AI functions for specific pedagogical goals and task characteristics and to integrate AI into lesson preparation, instruction, feedback, assessment, and professional learning. The focus is not the number of tools used, but task–tool fit. The same AI function may improve learning quality in one context and produce cognitive substitution in another.

Application therefore involves at least task analysis, tool selection, prompt design, output revision, and pedagogical integration. Teachers should first clarify the educational problem to be solved and then decide whether AI is appropriate, rather than first acquiring a tool and then searching for a use case. The central judgment is: Does this use of AI improve the original educational task, and might the learning objective actually be better served without AI?

5.3.3 Evaluating AI

Evaluation is the critical hub of teacher AI literacy in the age of generative AI. The more complete and natural AI output appears, the more teachers need the ability to judge it at a second order. Evaluation must include not only factual accuracy, but also logical coherence, evidential reliability, disciplinary accuracy, age appropriateness, cultural bias, fairness, and pedagogical value.

Evaluation cannot stop at a general awareness that "AI may make mistakes." It must be translated into executable verification strategies. Important factual claims should be checked against authoritative sources; subject-specific materials should be compared with curriculum standards and professional literature; and assessment recommendations should be reconsidered in light of students' actual work and classroom evidence. The goal of teacher AI literacy is not to make AI produce a correct answer on the first attempt, but to establish a verification process that makes it difficult for errors to enter teaching directly.

5.3.4 Regulating AI

AI self-regulation refers to teachers' ability to control the frequency, depth, and task scope of AI use and to avoid automation dependence and excessive cognitive outsourcing driven by convenience. This capacity is essential because "AI can do it" and "AI should do it" are not the

same proposition. Some tasks may be completed efficiently by AI but still hold important professional learning value for teachers or cognitive developmental value for students and therefore should not be fully outsourced.

Teachers need what may be called a retention judgment: which forms of professional reasoning should remain with the teacher, which student tasks should preserve productive difficulty, and which stages can appropriately use AI to increase efficiency. Self-regulation also includes monitoring one's own patterns of dependence—for example, whether AI is invoked habitually when it is unnecessary or whether independent lesson preparation and disciplinary judgment are gradually declining. The central question is: Even if this task can be delegated to AI, should human cognitive involvement be retained in order to sustain the development of teacher and student capabilities?

5.3.5 Collaborating with AI

Human–AI collaboration is not simply a matter of "the teacher does one part and AI does another." It refers to the teacher's ability to design the roles of both parties dynamically according to task characteristics. The concept of hybrid intelligence proposed by Dellermann et al. (2019) emphasizes complementarity between human and artificial intelligence. In educational settings, this complementarity needs to be specified more precisely: AI is well suited to rapid generation, comparison, and large-scale information processing, whereas human teachers remain indispensable for goal setting, contextual interpretation, relational judgment, value trade-offs, and responsibility.

High-quality collaboration is typically iterative. The teacher defines the task framework, AI produces alternatives, the teacher verifies and selects among them, the material is revised for the classroom context, and AI may be asked to supplement information when necessary before the teacher makes the final educational decision. Mature collaboration does not maximize AI participation. It finds an appropriate human–AI configuration for each task. The central question is: How should tasks be distributed between humans and AI so that efficiency and quality improve without weakening educational agency?

5.3.6 AI Ethics and Professional Responsibility

Ethics and professional responsibility form the final boundary of teacher AI literacy. Even if a lesson plan, assessment comment, or feedback text is generated by AI, once a teacher chooses to use it with students, it becomes part of the teacher's professional action. AI may provide recommendations, but it cannot assume the teacher's ultimate responsibility for students, fairness, privacy, or educational outcomes.

This dimension includes data privacy, consent boundaries, algorithmic bias, intellectual property, explainability, fairness, and accountability. More fundamentally, it requires a professional commitment to the principle that responsibility cannot be outsourced. Teachers should be able to explain where AI participated, which consequential judgments were made by the teacher, and how problems can be traced and corrected. The central question is: If an AI-assisted decision leads to error or harm, can the teacher explain why it was adopted and take responsibility for correcting it?

5.4 Hierarchical Relationships: From Basic Understanding to Professional Agency

The six dimensions are not merely parallel categories. They can be understood as three progressive levels. The first is a basic cognition and functionality level, comprising understanding AI and applying AI, which addresses whether teachers can approach and use AI appropriately. The second is a professional judgment and regulation level, comprising evaluating AI and regulating AI, which addresses whether teachers should trust, adopt, or continue using AI. The third is a collaborative agency and responsibility level, comprising human–AI collaboration and AI ethics and professional responsibility, which addresses how the human–AI relationship should be designed, who retains ultimate decision authority, and who bears responsibility.

This hierarchy means that the development of teacher AI literacy cannot stop at the first level. A teacher may possess strong tool-use competence, but if evaluation and regulation are weak, AI use may still be high risk. Mature teacher AI literacy should reach the third level, at which teachers actively design the human–AI relationship and retain control over educational purposes and consequences. The developmental trajectory can therefore be summarized as: tool adoption → critical use → active regulation → collaborative design → professional leadership.

5.5 Boundaries with Adjacent Concepts: Teacher AI Literacy Is Not Equivalent to AI Use, AI Self-Efficacy, or AI Readiness

Reconceptualizing teacher AI literacy also requires clearer boundaries with related constructs. First, frequency of AI use reflects the extent of behavior but not the quality of judgment. Second, AI self-efficacy reflects teachers' beliefs about their ability to perform AI-related tasks; high self-efficacy may encourage use but does not necessarily produce more accurate fact-checking or ethical judgment. Third, attitudes toward AI and intention to adopt it indicate willingness to use technology, not the ability to use it responsibly. Fourth, AI readiness

typically concerns the knowledge, resources, beliefs, and conditions available before entering an AI-rich environment. It overlaps with AI literacy but is more closely concerned with whether a teacher is prepared to adopt AI.

Teacher AI literacy is also related to TPACK and teachers' digital competence, but it cannot be fully replaced by either. TPACK emphasizes the integration of technology, pedagogy, and content knowledge and is highly valuable for explaining how technology enters teaching. Teachers' digital competence provides a broader framework for digital professional practice. The distinctive feature of teacher AI literacy is that generative AI does not merely execute tool functions; it can generate knowledge, make recommendations, and simulate decision-making. This creates more pronounced problems of factual reliability, bias, automation dependence, and accountability. Teacher AI literacy must therefore extend beyond traditional technology-integration competence to include verification of AI output, regulation of AI involvement, and management of human–AI responsibility.

5.6 Operating Mechanism: Teacher AI Literacy as a Cyclical Process of Professional Practice Rather Than a Static Competency List

A six-dimensional checklist alone is still insufficient to explain how teacher AI literacy operates in real practice. This article therefore proposes that teacher AI literacy should be understood as a cyclical professional process: defining the educational task → judging AI suitability → allocating tasks between human and AI → generating AI output → verifying evidence and exercising professional evaluation → translating output into the teaching context → confirming responsibility → reflecting and updating capability.

The process begins not with AI, but with the educational task. Teachers first clarify learning goals, learner needs, and risks, and only then decide whether AI is appropriate. Once AI is used, teachers continuously verify output and adapt it to context. After use, they should reconsider whether AI actually improved teaching and whether new forms of dependence, bias, or data risk were introduced. The results of this reflection then shape subsequent AI use, creating a dynamic learning cycle.

This cyclical mechanism also highlights the developmental nature of teacher AI literacy. Teachers cannot acquire AI literacy permanently through a single training event because model capabilities, platform rules, policy environments, and educational contexts all change. What remains relatively stable is not proficiency with a particular tool, but the judgment cycle itself. As long as teachers maintain a professional process of purpose-first reasoning, suitability

judgment, evidence verification, responsibility attribution, and reflective updating, their AI literacy can remain transferable even as specific technologies change.

5.7 Maturity of Teacher AI Literacy: From "Making AI Do Tasks" to "Designing the Boundaries of AI Participation in Education"

On the basis of the preceding framework, teacher AI literacy can also be understood as a maturity continuum. At the initial stage, teachers focus on tool adoption and on making AI complete tasks. At the second stage, effective use, teachers begin to compare tools and prompting strategies. At the third stage, critical use, teachers can identify errors, verify sources, and judge pedagogical appropriateness. At the fourth stage, active regulation, teachers can restrict the scope of AI use and avoid unnecessary cognitive outsourcing. At the fifth stage, professionally led human–AI collaboration, teachers can design how AI participates while retaining control over educational purposes, consequential judgments, and the boundaries of responsibility.

The maturity perspective is important because it challenges the linear assumption that more AI use necessarily means greater AI literacy. High-level teacher AI literacy may sometimes be expressed through less AI use because teachers can recognize tasks for which AI adds little value or introduces excessive risk. In other words, mature AI literacy includes knowing how to use AI and knowing when not to use it; it includes inviting AI into a task and knowing when to make it exit. This is a central distinction between teacher AI literacy and general tool proficiency.

6. Conclusion

Generative AI is changing the relationship between teachers, knowledge, instructional tasks, and professional judgment. Because AI can now generate content, analyze problems, formulate feedback, and offer recommendations, defining teacher AI literacy mainly by tool use would underestimate the challenge that generative AI poses to teacher professionalism.

This article therefore reconceptualizes teacher AI literacy as an integrated professional capacity grounded in educational purposes, professional judgment, ethical responsibility, and human–AI professional agency. The proposed six dimensions—understanding, applying, evaluating, regulating, collaborating, and taking responsibility—describe a progression from basic technological understanding to critical judgment and, ultimately, to professionally led human–AI collaboration.

Technical competence remains necessary, but it should be subordinate to educational judgment. Teachers need to decide not only what AI can do, but whether it should be used in a particular task, how its outputs should be verified and adapted, and who remains accountable for the result. Mature teacher AI literacy is therefore reflected less in the amount of work delegated to AI than in teachers' ability to define the purposes, conditions, boundaries, and limits of AI participation in education.

AUTHOR CONTRIBUTIONS

Lu Song: Conceptualization, Methodology, Writing–original draft, Writing–review & editing, Project administration, and Supervision; Rongwei Ni: Conceptualization, Methodology, Formal analysis, Writing–review & editing, and Validation; Xiao Wei: Investigation, Resources, Writing–review & editing, and Validation; Xu Zhang: Investigation, Visualization, Writing–review & editing, and Validation.

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