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Teacher AI Literacy and Readiness for AI-Enhanced Instruction: A Scoping Review of Competencies, Barriers, and Professional Development in Education

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Abstract. The growing presence of artificial intelligence (AI) in classrooms has placed teacher preparation in a challenging position, as educators are expected to utilize tools that influence lesson design, instruction, assessment, feedback, and student support, while formal training has not always advanced at the same pace. Consequently, the central question is no longer whether AI will become integrated into educational practice, but what preparation enables teachers to use it with pedagogical judgment, ethical awareness, and institutional support. This scoping review examined recent literature on teacher AI literacy and readiness for AI-enhanced instruction, focusing on required competences, barriers to classroom use, theoretical models, and professional development responses. Searches were conducted in Web of Science and Scopus databases for studies published from January 2021 to April 2026, following a PRISMA-ScR-oriented process. After duplicate removal, screening, eligibility assessment, and thematic analysis, 70 studies were included. The findings indicate that teacher AI literacy extends beyond technical knowledge to include understanding system capabilities and limitations, adapting tools to classroom needs, critically evaluating generated outputs, and determining when AI use genuinely supports learning. Readiness is shaped by self-efficacy, perceived usefulness, institutional support, resources, infrastructure, and the preservation of professional responsibility. The evidence also reveals a mismatch between structural barriers and the short-term training commonly offered, highlighting the need for sustained, contextualized, and practice-based professional development.

Keywords: AI literacy; teacher readiness; teacher training; AI ethics; scoping review

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1. Introduction

Teacher's today is encountering artificial intelligence (AI) with unprecedented speed. Until recently, many members of the academic community still viewed AI as a technology of the future – one that had not yet become fully integrated into schools but was expected to transform teaching and learning. That situation has changed. Today, many teachers use AI to support lesson planning, provide feedback on students' assignments, create instructional materials, assist with assessment, facilitate learning, and develop classroom content. Therefore, while educational possibilities exist through the use of AI, it is no longer a technology waiting to be adopted; it has already become embedded in many of the everyday activity's teachers undertake to plan, support, and evaluate student learning.

This transition requires teachers to do more than simply adapt to a new technology. It also requires them to reconsider aspects of their professional role. Teachers have traditionally decided what to teach, how to teach it, and how to assess student learning. Today, however, they must also determine whether an AI-generated response supports or hinders learning, whether the potential benefits outweigh the associated risks, and when AI-generated outputs should be accepted, adapted, or disregarded. Recent research highlights this shift, particularly in relation to ChatGPT, Ai-assisted student writing, feedback generation, and classroom experimentation (Akhmedjanova et al., 2025; Kurniawan et al., 2026; Truong & Tran, 2026).

This is why the role of the teacher remains indispensable. Although AI can generate text, images, examples, questions, and feedback, it cannot replace the teacher's professional responsibility to determine what is appropriate for a specific group of students. Educators may approach these tools with enthusiasm and curiosity, but also with apprehension as AI begins to perform tasks that were once considered integral to their professional role. This tension is evident in the reviewed literature, where educators are expected to use powerful and potentially beneficial tools that remain largely under-regulated by institutions. Consequently, confidence in using AI is important, but it must be supported by pedagogical criteria, ethical standards, and institutional policies that promote responsible use (Aquino & Perez, 2025; Bautista et al., 2024; Chan & Tang, 2024).

In this review, teacher AI literacy is not understood as merely being familiar with an application, knowing where to click, writing prompts, or obtaining quick answers. Rather, it is defined as the capacity to make informed decisions about when and how AI can support teaching without displacing professional judgement. Across the reviewed studies, teacher AI literacy encompasses knowledge of AI-related concepts, critical review of generated outputs, recognition of ethical dilemmas, adaptation of instructional materials, and the ability to ensure that human judgment remains central to classroom decision-making (Cabero-Almenara et al., 2025; Chu & Ma, 2026; Ríos Gonzales et al., 2025).

This distinction is important, as teachers remain responsible for deciding whether an output is valid, aligned with curriculum objectives, responsive to student needs, and useful for learning. Readiness is related to literacy, but it is not the

same concept: a teacher may know how an AI tool works and still feel unprepared to use it with students because of low self-efficacy, unclear assessment rules, institutional ambiguity, plagiarism concerns, or limited access to resources and infrastructure. For this reason, readiness is considered in this context as a situated professional condition rather than a simple attitude toward technology (Aksit et al., 2025; Hsu et al., 2025; Ruiz & Yambao, 2026).

The literature also demonstrates that preparedness varies across educational levels, disciplines, and institutional contexts, since teachers' use of AI depends on prior technological experience, pedagogical style, emotional disposition, resources, administrative expectations, and the type of learning being promoted. Pre-service teachers often express enthusiasm and apprehension, while experienced educators tend to connect preparedness with digital literacy, confidence, professional well-being, and school support (Duc et al., 2025; Karataş & Yüce, 2024; Mnguni et al., 2024; Pahrudin et al., 2025; X. Wu & Annamalai, 2026; Zhao et al., 2025). The barriers identified are therefore not only technical but also operational, ethical, and institutional, including limited training, unequal infrastructure, unclear instructional value, weak administrative support, and uncertainty about whether AI tools fit teaching practices or learning objectives (Al-Azzawi, 2026; Aquino & Perez, 2025; Pratiwi et al., 2025; Srirevathi & Aravind, 2025; Tuan et al., 2025).

Ethical concerns also remain central, particularly those related to bias, plagiarism, misinformation, student privacy, dependence on AI-generated output, authorship, originality, and acceptable academic use (Al Asyari et al., 2025; Alasgarova & Rzayev, 2025; Aydeniz, 2025; Caling et al., 2025; Rajabi, 2026). For this reason, teacher training cannot be limited to isolated workshops, since the literature also points to mentoring, communities of practice, curricular reform, project-based learning, and longer-term institutional support as more sustainable responses (Ayesha et al., 2026; Estaiteyeh & Mindzak, 2025; Hoa et al., 2026; Kitcharoen et al., 2024; Lamrabet et al., 2025; Tran et al., 2024; Zulianti et al., 2024).

Clarifying these distinctions is important because terms such as competence, literacy, preparedness, readiness, adoption, acceptance, intention, anxiety, and self-efficacy are often used interchangeably, despite referring to different constructs (Ismaniati et al., 2025; Pan et al., 2025; Prosenjak & Jakupčević, 2025; Sadykova & Kayumova, 2024; Thuy et al., 2025; Tsiani et al., 2025). Preparing teachers for AI therefore requires an understanding of what they need to know, the factors that constrain their ability to use AI responsibly, and the forms of sustained development that enable them to use AI with pedagogical purpose.

Therefore, this study conducts a scoping review of teacher AI literacy and readiness for AI-enhanced instruction. Rather than asking whether AI is beneficial or harmful to education in general, the review addresses a more practical and professional question: How is teacher preparation for AI currently being framed, and what remains unaddressed in that framing? The review focuses on three areas: competency needs, barriers to preparation, and the theoretical frameworks and professional development models used to explain or support teacher

preparation. The evidence is interpreted through a competence–constraint–development lens.

The contribution of this review lies in bringing together two bodies of literature that are often treated separately: teacher AI literacy and teacher readiness for AI-enhanced instruction. Considered together, they demonstrate that teacher preparation extends beyond the acquisition of technical skills. Rather, it is a process of professional development that enables teachers to understand the capabilities and limitations of AI, apply it appropriately within their subject areas, protect students from potential harm, and navigate the organizational conditions that can either support or constrain its responsible use.

To minimize conceptual ambiguity, Table 1 presents the key concepts used as working definitions in this review. These definitions provide a framework for organizing the synthesis of the existing literature and are not intended to restrict the future development of the field.

Table 1: Working definitions of key constructs in teacher AI preparation

Construct	Working definition in this review	Significance of the distinction
AI literacy	A teacher's capacity to understand AI, interpret its outputs critically, recognize risks, and connect the tool to pedagogical purposes.	It is not only technical use; it includes judgment.
Competence	Observable knowledge, skills, and practices that allow a teacher to use AI in teaching, assessment, feedback, or planning.	It describes what teachers can do, not necessarily whether they are prepared.
Readiness	A situated condition shaped by confidence, self-efficacy, perceived usefulness, institutional support, and feasibility in real classrooms.	A teacher may be competent but still not ready if the context is unsafe or unsupported.
Preparedness	The broader state produced by training, experience, curriculum exposure, and professional learning opportunities.	It points to formation over time, not a single workshop.
Adoption and acceptance	The decision or intention to use AI, often explained through perceived usefulness, ease of use, norms, and institutional expectations.	Acceptance does not guarantee responsible pedagogical implementation.
Professional development	Formal and informal learning that helps teachers move from awareness to responsible classroom use.	It must respond to structural barriers, not only individual skill gaps.

The same distinction informs the analytical model adopted in this review. As illustrated in Figure 1, competence may contribute to teacher readiness, but it is not sufficient on its own. Readiness can be constrained by institutional, ethical, pedagogical, and infrastructural factors. Professional development is most likely to strengthen readiness when it extends beyond brief or isolated interventions and

is grounded in the authentic contexts in which teachers make decisions, teach, and implement AI in their classrooms.

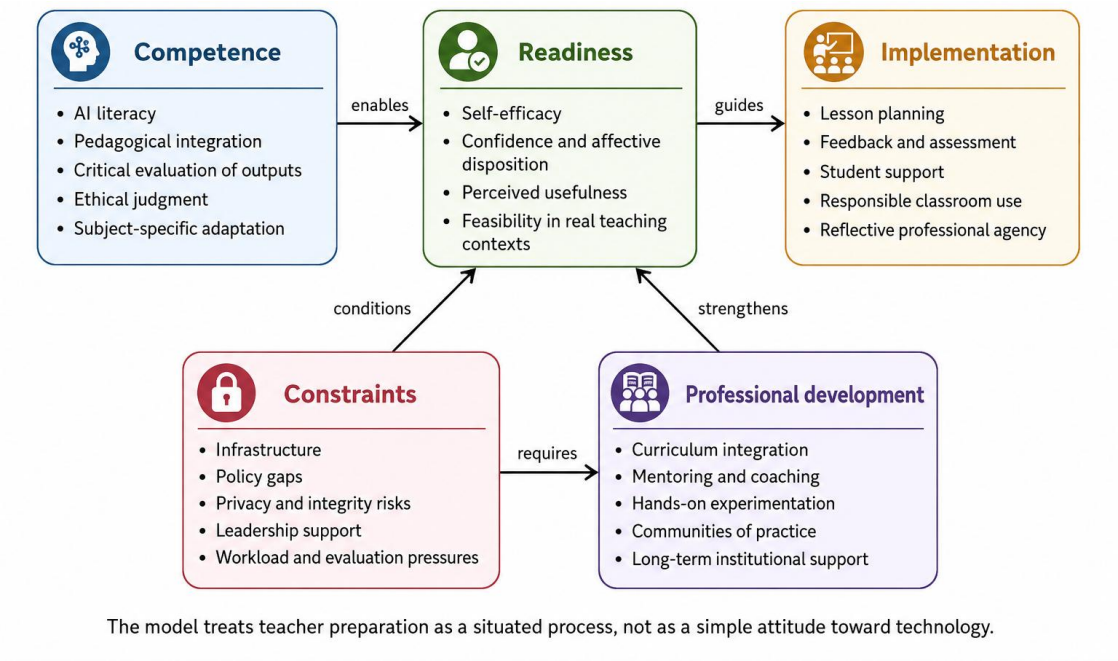

Figure 1: Competence–constraint–development model for teacher AI readiness

The focus of this review is based on the following five research questions.

RQ1. How has teacher AI literacy been defined or framed in current research about using AI in instructional methods?

RQ2. What are the key areas of preparation for teachers that are most commonly cited as a factor in their ability to effectively utilize AI in instruction?

RQ3. What factors inhibit teachers from using AI responsibly and pedagogically within educational settings?

RQ4. What types of professional development programs exist to support the improvement of teachers' AI literacy and preparedness?

RQ5. Where are there gaps in terms of methodology and theory that continue to remain unaddressed in current studies related to AI-enhanced teaching?

2. Literature Review

The reviewed literature indicates a rapidly evolving field, as AI is no longer regarded as a distant possibility but as a technology already embedded in teachers' everyday work, from lesson planning and student feedback to writing support, assessment, language teaching, and content creation. However, the main concern is not merely access to these tools, which are often available through free or low-cost platforms, but the pedagogical, ethical, and institutional conditions under which they can be used effectively and professionally (Akhmedjanova et al., 2025; Espartinez, 2025; Truong & Tran, 2026; Wardat & Akour, 2025).

Accordingly, the literature review is organized around four interconnected topics: what teachers need to know to integrate AI into instructional practice; how readiness develops through institutional support, contextual factors, and

professional confidence; which theoretical frameworks explain teachers' use, adoption, acceptance, and preparedness; and what forms of professional learning can reduce barriers while creating meaningful opportunities to understand AI and its educational applications. The final topic is particularly important because the effective implementation of AI requires more than a single workshop. It demands technical knowledge, ethical judgment, pedagogical adaptation, and institutional conditions that enable teachers to preserve the educational value of their practice. For this reason, the review begins with teacher AI literacy, as it provides the foundation for understanding what teachers are expected to know, question, interpret, and apply when AI becomes integrated into teaching practice.

2.1 Teacher AI Literacy

One of the key themes emerging from the reviewed literature is that teacher AI literacy cannot be reduced to technical proficiency. In other words, it is not sufficient for teachers to know how to use a tool, write a prompt, or obtain a quick response. Although these may be important initial skills, they do not fully capture what teachers need when AI becomes integrated into their pedagogical practice. Across the reviewed studies, teacher AI literacy encompasses conceptual understanding, ethical awareness, the critical evaluation of AI-generated outputs, and the ability to align AI use with curricular and pedagogical decision-making (Cabero-Almenara et al., 2025; Nguyen, 2026; Ríos Gonzales et al., 2025; Sartor-Harada & Azevedo-Gomes, 2025; Tuan et al., 2025).

This distinction is important because the teacher is not expected to use AI mechanically. The teacher needs to understand what the tool is doing, what its limits are, and how its output should be interpreted before it is integrated into the classroom. In this sense, AI literacy becomes an integral component of professional judgment. It enables teachers to determine whether an AI-generated explanation, activity, example, or assessment resource is appropriate for a specific learning purpose, or whether it needs to be modified, questioned, or rejected.

This area has also been examined from other perspectives, including the relationship between AI literacy and teacher professional development, prompt competence, scenario-based diagnostic assessment, AI-assisted gamified assessment, and intelligent technological pedagogical content knowledge (TPACK) (Artykbaeva et al., 2026; Basty et al., 2025; Sukyadi et al., 2025; Ye et al., 2025). The cited studies show that AI literacy is not an isolated skill but part of a broader preparation process that helps teachers create more authentic educational experiences.

Teacher AI literacy becomes particularly evident in studies on ChatGPT, conversational agents, and AI-supported instruction. In these contexts, teachers are expected to design effective prompts, critically evaluate AI-generated responses, identify misinformation, and guide learners without allowing AI-generated content to replace human interaction or subject-specific judgment (Allehyani & Algamdi, 2023; Andewi et al., 2025; Konstantinidou et al., 2026; Kurniawan et al., 2026). Therefore, teacher AI literacy can be understood as the combination of knowledge, critical judgment, and pedagogical intention required

to use AI while ensuring that the teachers' professional judgment remains central to classroom decision-making.

2.2 Teacher Readiness for AI-Enhanced Instruction

Teacher readiness is another important construct for understanding AI-enhanced instruction because it encompasses both the cognitive and affective dimensions of teachers' preparation to use AI in educational settings. This construct includes self-efficacy, confidence, attitudes toward AI, perceived usefulness, and beliefs about whether AI can be used effectively in real classroom conditions (Aksit et al., 2025; Amandoron et al., 2025; Bautista et al., 2024; Hsu et al., 2025; Ruiz & Yambao, 2026).

Although pre-service teachers may recognize the potential of AI in enhancing instruction and generally hold favourable attitudes toward its use, they often report lower confidence than practicing teachers and faculty in applying AI in actual classroom settings. Practicing teachers and faculty, on the other hand, tend to focus more on feasibility, including adequate training, organizational support, pedagogical alignment, and compatibility with existing curriculum and assessment practices (Bae et al., 2024; Chan & Tang, 2024; Qian et al., 2026; Uyanik et al., 2024).

2.3 Theoretical and Conceptual Frameworks

The theoretical perspectives underpinning the reviewed studies are well established but dispersed across different conceptual approaches. Many studies draw on TPACK and AI-adapted versions of TPACK to examine how AI, pedagogy, and curriculum interact in educational settings (Bautista et al., 2024; Chu & Ma, 2026; Jiang et al., 2026; Mishra & Koehler, 2006; Rajapakse, 2026; Torres Casierra et al., 2025). Others rely on technology acceptance models, such as the technology acceptance model (TAM) and the unified theory of acceptance and use of technology (UTAUT), to explain why teachers use or reject AI (Davis, 1989; Musood & Kaur, 2025; Venkatesh et al., 2003). A third group draws on digital competence frameworks, such as DigCompEdu, to conceptualise teachers' professional capacity for effective digital practice (Cabero-Almenara et al., 2025; Redecker, 2017).

These frameworks do not directly compete; rather, each addresses a different aspect of AI integration in education. TPACK explains the relationship between AI, content knowledge, and pedagogy. TAM and UTAUT explain technology acceptance, intention, and perceived usefulness. DigCompEdu situates AI within the broader context of professional digital competence. However, none of these frameworks fully explains why a teacher who understands AI may still hesitate to use it because of concerns about privacy, plagiarism, inadequate technological support, or unclear institutional policies. For this reason, the literature was interpreted through the lens of competence, constraints, and development rather than technology adoption alone.

Similar fragmentation is evident in studies drawing on maturity models, digital competence frameworks, the fuzzy analytic hierarchy process, innovation diffusion theory, social learning theory, and constructivist approaches.

Collectively, these perspectives broaden the field and reinforce the view that teacher preparation for AI is both a pedagogical and a socio-technical endeavor (Anwar et al., 2025; Mamontov, 2025; Perante et al., 2025; Ramadhan et al., 2024; Romero García et al., 2025; Tulang, 2025).

2.4 Barriers to AI Integration in Teaching

Research has identified several barriers that challenge overly optimistic views of AI as a teaching aid. Although some teachers lack adequate technological resources, the problem also includes insufficient training, inconsistent institutional support, unstable infrastructure, and limited examples of how to integrate AI effectively into classroom practice (Aquino & Perez, 2025; Pratiwi et al., 2025; Srirevathi & Aravind, 2025).

Another group of barriers concerns teacher professionalism. Educators have expressed concerns about plagiarism, algorithmic bias, misinformation, student privacy, overreliance on AI, and the possible weakening of teacher–student relationships. These concerns matter because they directly affect how teachers understand their role when AI becomes part of instructional practice (Alasgarova & Rzayev, 2025; Aydeniz, 2025; Caling et al., 2025; Rajabi, 2026).

Other barriers are specific to particular instructional contexts. For example, AI-supported formative assessment, language instruction, and science education raise concerns about the accuracy of AI-generated feedback, prompt design, cognitive offloading, hardware capacity, and the need to preserve meaningful interaction between teachers and students (Jere et al., 2024; Steyn Mokgwathi & Ngoveni, 2026; Y. Wu & Derakhshan, 2025).

2.5 Professional Development for AI-Enhanced Instruction

The literature consistently identifies professional development as essential for AI-enhanced instruction, particularly in relation to introducing AI concepts, promoting ethical use, and supporting classroom applications (Estaiteyeh & Mindzak, 2025; Kitcharoen et al., 2024; Lamrabet et al., 2025). In initial teacher education, AI preparation is commonly associated with curriculum reform, AI-related courses, competency-based training, and project-based learning. Timing is also critical: AI preparation should begin before teachers enter the profession, not only after they are already teaching (Bautista et al., 2024; Hoa et al., 2026; Mukhambetaliyeva et al., 2026). However, awareness of AI tools alone is insufficient. Teachers also need hands-on experience, TPACK-oriented training, gamified learning materials, and neural-network-based tools that enable them to connect AI with real educational decision-making (Romero García et al., 2025; Soboleva et al., 2025; Sukyadi et al., 2025; Ye et al., 2025).

Differentiated support is also required at the school level, as novice teachers, experienced teachers, and those working in low-resource settings have different professional development needs. Mentoring, collaborative experimentation, and communities of practice are likely to provide more sustainable support than one-time exposure to AI-related information (Kurniawan et al., 2026; Pahrudin et al., 2025; Tran et al., 2024). Ultimately, the challenge is no longer to make teachers

aware of AI but to support them in making informed and responsible decisions about its use in educational decision-making.

3. Methodology

This study employed a scoping review, as the terminology surrounding teacher AI literacy and readiness is still evolving. The purpose was not to evaluate the effectiveness of interventions or compare professional development models, but to examine how the literature defines these constructs, identify the barriers that constrain teacher preparation, and synthesize the professional development responses proposed to address them. The review followed established scoping review principles, in which mapping concepts, clarifying conceptual boundaries, and identifying gaps are central objectives (Arksey & O'Malley, 2005; Levac et al., 2010).

To provide a transparent audit trail, the review process was organized into nine stages: research design, search strategy, eligibility criteria, reviewer role and coding consistency, screening, extraction, synthesis, quality considerations, and methodological limitations. This structure was necessary because the reviewed studies employed different methods, addressed different educational levels, and relied on different theoretical perspectives. Without a clearly defined audit trail, studies examining teachers' attitudes toward AI, AI competence, AI literacy, and professional development could easily have been treated as though they were addressing the same research question.

3.1 Research Design

The research design was informed by established scoping review principles and reported, where applicable, in accordance with the PRISMA-ScR and PRISMA 2020 guidelines for the study selection process (Page et al., 2021; Tricco et al., 2018). Studies included in the review were published between January 2021 and April 2026. This timeframe was selected because research on teachers and AI expanded following the widespread emergence of generative AI in education. A scoping design was considered appropriate because the available evidence comprised surveys, qualitative studies, mixed-method studies, case studies, and framework-based analyses, making a conventional effect-size synthesis neither feasible nor appropriate.

3.2 Search Strategy

A comprehensive literature search was conducted in the Scopus and Web of Science databases in April 2026. The literature search included articles published between January 2021 and April 2026 to identify current trends, research findings, and emerging issues related to teacher AI literacy, teacher readiness for AI-enhanced instruction, and AI-supported teaching practices. The search strategy comprised three conceptual blocks: artificial intelligence in education, a focus on teacher-related populations, and constructs associated with AI literacy or readiness. Searches were conducted across titles, abstracts, and keywords where supported by each database. The search equation used to query Scopus was:

> TITLE-ABS-KEY((“artificial intelligence” OR “AI” OR “Generative AI” OR “GenAI” OR “AI in education”) AND (“Teacher*” OR “Educator*” OR “Faculty” OR “Lecturer*” OR “Pre-service Teacher*” OR “In-service Teacher*” OR “Teacher Educator*”) AND (“AI Literacy” OR “Artificial Intelligence Literacy” OR “Competence” OR “Competency” OR “Readiness” OR “Preparedness” OR “Adoption” OR “Acceptance” OR “Perception*” OR “Attitude*” OR “Self-Efficacy”)).

The Web of Science search equation was adapted using the Topic Search field, as follows:

> TS=((“artificial intelligence” OR “AI” OR “generative AI” OR “GenAI” OR “AI in education”) AND (“teacher” OR “educator” OR “faculty” OR “lecturer*” OR “pre-service teacher*” OR “in-service teacher*” OR “teacher educator*”) AND (“AI literacy” OR “artificial intelligence literacy” OR “competence” OR “competency” OR “readiness” OR “preparedness” OR “adoption” OR “acceptance” OR “perception*” OR “attitude*” OR “self-efficacy”))**.

The literature search returned 2047 records, including 1265 from Scopus and 782 from Web of Science.

3.3 Eligibility Criteria

Four inclusion criteria were defined before screening. Studies were included when they met the following conditions:

1) The study addressed teachers or teacher-related professional groups, including pre-service teachers, in-service teachers, university faculty, lecturers, teacher educators, education practitioners, or school-level professionals directly involved in teacher preparation or instructional implementation.
2) The study deals with at least one of the central themes identified by the review (“AI literacy”, “Readiness to Use AI-based Instructional Materials”, “Teacher Competence in Using AI in Education”, “Barriers to Educational Integration of AI”, “Professional Development for Teachers in Using AI in Teaching”).
3) The study is set in an educational setting (school education, higher education, teacher education, instruction).
4) The study has sufficient conceptual, empirical, or analytical detail to enable extraction and synthesis.

Studies were excluded when they focused only on students without addressing the teacher's role in AI-related learning; when they only described the development of technical systems, algorithms, or other technologies; or when they had no direct relationship with preparing teachers to use AI to support instructional practice. Non-academic sources, brief summaries, and records without sufficient conceptual or empirical detail on teacher preparation for AI were also excluded. These exclusions clarified the purpose of the review: to examine how educators are being prepared to use AI responsibly in professional practice, rather than to address all aspects of AI in education.

3.4 Reviewer Role and Coding Consistency

The selection and extraction of studies were undertaken by a single researcher; therefore, no inter-rater reliability statistic, such as Cohen's kappa, was calculated. To enhance consistency, an a priori eligibility matrix was developed, unclear cases were reviewed repeatedly, and documentation was maintained to ensure alignment between the research questions, eligibility criteria, data extraction fields, and final themes. Records that raised uncertainty were not excluded immediately but were retained for further assessment until it was determined whether they contributed meaningfully to understanding teacher AI literacy for AI-enhanced instruction.

3.5 Screening Procedure

The search and review process followed four stages: identification, screening, eligibility assessment, and inclusion. Titles and abstracts were initially screened to identify studies directly related to teachers and their preparation for AI use. The remaining records were then assessed against the inclusion and exclusion criteria, with particular attention to the study population, educational context, AI focus, and relevance to teacher AI literacy, readiness, competence, barriers, frameworks, or professional development. Following this process, 70 studies were included in the final evidence base, as illustrated in Figure 2 below.

3.6 Data Extraction

Information from each study included was organized in a structured data extraction table, which served not only as a record of the evidence but also as the primary basis for comparison and synthesis. This table enabled systematic examination of the studies characterised teachers, AI tools and applications, required competences, identified barriers, theoretical perspectives, and professional development approaches. The extraction field included bibliographic information, publication year, journal, DOI, research aim, educational level, participant group, research design, AI tool or application, theoretical perspective or paradigm, definitions of AI literacy and teacher readiness, competence indicators, barriers, professional development approaches, ethical concerns, and implications for teacher education and policy.

3.7 Data Synthesis

Data analysis combined descriptive mapping with thematic interpretation. The descriptive component organized the studies according to publication year, participant group, educational setting, methodology, and primary focus, while the thematic component identified broader patterns across the literature,

particularly those related to teacher AI literacy, readiness, barriers, ethical concerns, theoretical frameworks, and professional development. Thematic interpretation was then used to examine the significance of these patterns. Examples included the frequency with which ethical issues were reported, the predominance of studies conducted in higher education, and the widespread reliance on professional development programs lasting less than one day, despite evidence that many barriers to AI integration are organizational rather than individual.

Recurring themes were coded using binary indicators for participant group, educational setting, methodology, AI type, competence theme, barrier theme, and professional development response. As individual studies could be assigned to more than one category, the resulting percentages were not mutually exclusive and were calculated based on the 70 included studies.

3.8 Quality Considerations

As this was a scoping review, no formal risk-of-bias assessment was undertaken. Such an assessment was not appropriate because the purpose was to identify and interpret a diverse body of literature on teacher preparation for AI-enhanced instruction, rather than to evaluate the effectiveness of interventions. Nevertheless, considerations of quality informed the extraction and synthesis process. Each study was assessed for its relevance to the research questions, clarity of reporting, conceptual or empirical detail, and usefulness for understanding teachers' interaction with AI. Publications that only listed "AI" as a keyword, without meaningful detail on teachers' experiences or preparation, were not included. Although this approach does not replace a full critical appraisal, it enhances the transparency of the evidence base. Accordingly, the findings should be interpreted as a conceptual and thematic synthesis of the field rather than as evidence that all included studies are of equivalent methodological quality.

3.9 Methodological Limitations

Several limitations should be considered when interpreting the findings of this review. First, the search was limited to two major databases, Scopus and Web of Science; consequently, relevant studies indexed elsewhere may not have been captured. Second, variation in the terminology used to describe AI literacy, teacher readiness, and teacher competence may have influenced the search results, as conceptually similar studies may have employed different terms. Third, because the review was conducted by a single researcher, it was not possible to calculate an inter-rater reliability statistic. Finally, the evidence base was uneven in its representation of certain groups and contexts. Studies focusing on higher education and in-service teachers were more prevalent than those examining school leadership, teacher educators, rural schools, or resource-constrained settings.

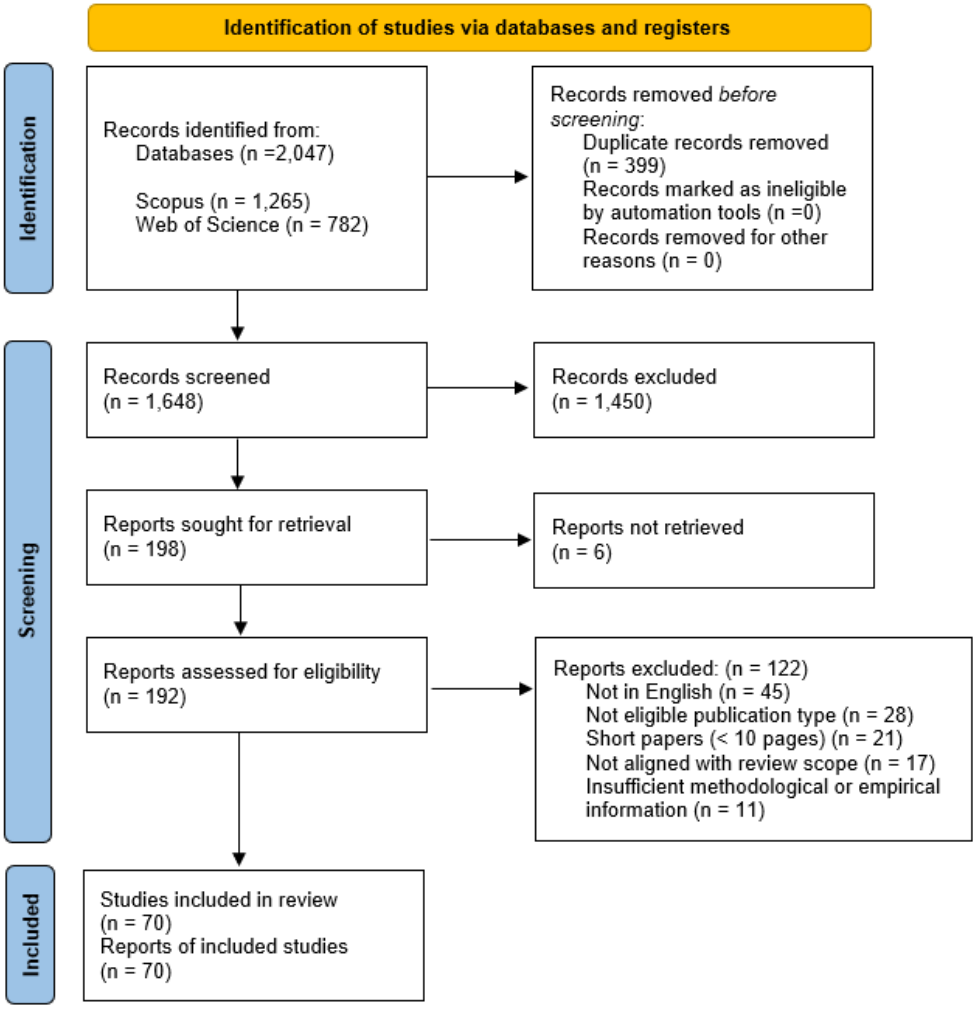

Figure 2: PRISMA-ScR flow diagram

Figure 2 illustrates the study selection process using the PRISMA-ScR flow diagram. The database search identified 2047 records, including 1265 from Scopus and 782 from Web of Science. After the removal of 399 duplicate records, 1648 records were screened by title and abstract. Of these, 1450 records were excluded because they did not meet the initial relevance criteria. A total of 198 reports were sought for retrieval, of which 6 could not be accessed. Consequently, 192 full reports were assessed for eligibility. During full-text eligibility assessment, 122 reports were excluded for the following reasons: not published in English (n = 45), ineligible publication type (n = 28), short papers with fewer than 10 pages (n = 21), not aligned with the review scope (n = 17), and insufficient methodological or empirical information (n = 11). As a result, 70 studies were included in the final review and used for the analytical synthesis.

4. Results and Findings

The 70 studies included in the final analysis are part of an increasing body of research on a topic that has grown exponentially over the last few decades. This research is highly concentrated in the last decade, with much of it developing new concepts to study teacher AI literacy (e.g., understanding how teachers can

effectively use AI), their readiness to incorporate AI-enhanced instructional methods, ethical issues surrounding AI in classrooms, and teacher training requirements. In addition to these themes, the literature was unevenly represented among different educational settings and participant groups.

Higher education and in-service teaching were the only two areas that appeared more often as educational settings than all others. Generative AI, ChatGPT, and similar technologies dominated the technology referenced throughout the reviewed literature. To provide a clear representation of the data analyzed in this literature review, this section will be divided into two sections. The Qualitative Findings section describes the primary thematic patterns identified through the comparative reading of the extraction matrix. The Quantitative Findings section summarizes the primary tendencies that describe the entire body of literature reviewed, including publication trends, participants' demographics, educational setting(s) where each study occurred, methodologies used in each study, and frequency of coded themes.

4.1 Qualitative Findings

The qualitative synthesis was organized around five interconnected themes. These themes are presented as complementary rather than discrete categories, reflecting the review's central conclusion that teacher preparation for AI involves the integration of multiple interrelated competencies rather than the development of a single skill.

First, the studies treat teacher AI literacy as more than the ability to operate tools. The teacher is expected to understand what AI can and cannot do, to interpret AI-generated outputs critically, to adapt suggestions to curricular goals, and to decide whether a tool is appropriate in a specific classroom situation. The reason AI literacy has been consistently tied to professional judgment, rather than simply to familiarity with technology, is that teachers are expected to do more than recognize or operate AI tools. They must also decide whether an AI-generated output is useful, limited, risky, or appropriate for a specific learning situation.

Second, readiness is perceived as a much less stable concept. The classroom is not just an abstract environment; it consists of students, assessment requirements, institutional expectations, family factors, privacy issues, and the teacher's level of self-assurance. Therefore, readiness in this context is pedagogically, emotionally, and organizationally based (Aksit et al., 2025; Amandoron et al., 2025; Ruiz & Yambao, 2026).

Third, there is no unified language for understanding the theoretical underpinnings of the field. TPACK and AI-TPACK provide insight into how teachers integrate AI with pedagogy and content; TAM and UTAUT provide explanations for how teachers accept and intend to use AI; and DigCompEdu and similar models provide guidance for locating AI within a larger professional competence framework. While this variety can be beneficial, it also suggests that the field does not yet have a comprehensive model explaining how competence, constraints, and development are interrelated.

Fourth, the recurrence of plagiarism, bias, privacy, misinformation, and loss of professional agency is especially important. It shows that teacher hesitation is not always resistance to innovation but sometimes a reasonable professional caution.

Fifth, one of the most prominent responses to the need for teacher preparation is institutional support through professional development. However, there is still no clear consensus on how much value each type of professional development actually provides. For example, short workshops may help open the conversation about AI-enhanced instruction, but the studies with stronger practical implications tend to point toward long-term curriculum integration, mentoring, hands-on learning activities, collaborative work, and sustained institutional support as more meaningful ways to prepare teachers for the responsible use of AI in education (Estaiteyeh & Mindzak, 2025; Hoa et al., 2026; Lamrabet et al., 2025; Tran et al., 2024).

4.2 Quantitative Findings

Following the qualitative synthesis, this section presents the main quantitative patterns identified across the included studies. In terms of distribution by year, a sharp increase was identified. One study was published in 2023, twelve in 2024, forty in 2025, and seventeen in the first four months of 2026. As shown in Figure 3, the 2026 publication count should be interpreted with caution because the year is incomplete. Nevertheless, the overall trend indicates a rapid increase in research interest following the emergence of generative AI in education.

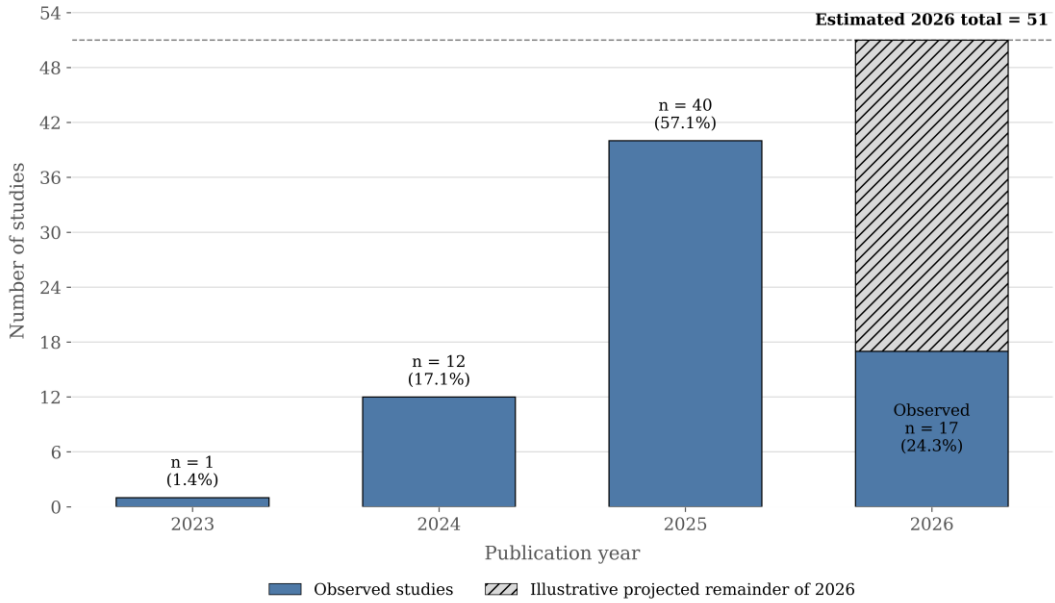

Figure 3: Distribution of reviewed studies by year of publication

Table 2 displays the main participant categories and educational settings represented in the reviewed studies.

Table 2: Participant groups and educational contexts in the reviewed studies

Dimension	Category	Frequency (n)	Percent (%)
Participant group	In-service teachers	33	47.1
	Pre-service teachers	24	34.3
	University faculty	13	18.6
	Teacher educators	2	2.9
	Lecturers	3	4.3
	Education practitioners	1	1.4
Educational context	Higher education	40	57.1
	School education	28	40.0
	General teaching context	11	15.7
	Teacher education	9	12.9

Note. Percentages in this table may exceed 100% because some studies included more than one participant group or educational context.

Table 2 demonstrates that the majority of studies in the review focus on both pre-service and in-service teachers, with a significant amount of school-based research. Therefore, it appears that research is emphasising professional development for practicing teachers rather than the needs of a more limited group, that is, teacher educators or other similar populations. On the other hand, the large number of studies conducted in higher education suggests that these institutions were among the first to explore the use of generative AI, likely because of their rapid adoption of writing, assessment, and student support technologies that incorporate generative AI (Akhmedjanova et al., 2025; Cabero-Almenara et al., 2025; Ríos Gonzales et al., 2025; Wardat & Akour, 2025).

To gain insight into how research in this area has been conducted, Table 3 presents an overview of the research methods reported in the studies included in the extraction matrix.

Table 3: Methodological profile of the reviewed studies

Methodological feature	Frequency (n)	Percent (%)
Quantitative studies	35	50.0
Qualitative studies	27	38.6
Mixed-methods studies	19	27.1
Survey-based studies	32	45.7
Studies using thematic analysis	26	37.1
Studies using interviews	18	25.7

Note. Methodological categories are not mutually exclusive. A mixed-methods study, for example, may also include surveys, interviews, and thematic analysis.

The methodological profile suggests that this is an active but still emerging field of research. Surveys and quantitative models predominate, whereas qualitative and mixed-method studies are more commonly employed to investigate teachers' professional experience, institutional contexts, and ethical considerations. Longitudinal and intervention-based studies remain relatively scarce.

Further analysis of the thematic coding in the extraction matrix highlights the core dimensions of teacher AI preparation that have received the greatest attention in the literature. Table 4 provides an overview of the most frequently identified

themes related to teacher competence, barriers to AI integration, and professional development responses.

Table 4: Main coded themes in the reviewed literature

Competence	Related theme	Frequency (n)	Percent (%)
Competence-related themes	Ethical awareness / responsible use	40	57.1
	Pedagogical integration	38	54.3
	Technical / digital competence	28	40.0
	Critical evaluation of AI outputs	25	35.7
	Data / analytics literacy	9	12.9
	Prompt-design competence	4	5.7
Barrier-related themes	Ethical / integrity concerns	43	61.4
	Pedagogical alignment challenges	28	40.0
	Infrastructure / resource constraints	26	37.1
	Institutional / policy gaps	15	21.4
	Low confidence / anxiety	13	18.6
Professional development themes	Workshops / training programs	55	78.6
	Curriculum integration / courses	26	37.1
	Hands-on practice	23	32.9
	Continuous ongoing development	20	28.6
	Collaborative / peer learning	19	27.1
	Mentoring / coaching	9	12.9

Note. The frequencies represent coded thematic occurrences in the extraction matrix. A single study could contribute to more than one theme.

Three relevant patterns are indicated in Table 4: ethical awareness and pedagogical integration are the most frequent competence themes; ethics, alignment, and infrastructure are the most visible barriers; and workshops remain dominant even though the literature increasingly calls for sustained support. Furthermore, generative AI is the most visible technology category in the corpus, followed by adaptive systems, chatbots, automated assessment, and ChatGPT. This confirms that current research activity is closely tied to the public expansion of generative AI in teaching and learning.

Collectively, the results suggest that AI-enhanced instruction depends less on the mere availability of tools than on teachers' capacity to use them with pedagogical judgment, ethical awareness, and institutional support.

5. Discussion

The large and growing body of research on generative AI in education is a significant outcome of the expanding use of AI in education. However, as with many rapidly developing fields of study, an increase in the number of studies does not necessarily lead to greater conceptual clarity. The evidence suggests that, although research on generative AI in education has expanded rapidly, the shared vocabulary and theoretical frameworks needed to interpret and integrate these findings have developed more slowly. One of the central concerns emerging from this review is what it means for teachers to be prepared to utilize AI. Preparation extends well beyond having access to AI tools, being willing to experiment with them, or possessing sufficient technical knowledge. It also requires the development of AI literacy.

In this context, literacy refers to an understanding of what AI is capable of doing, the ability to recognize its realistic capabilities and limitations, and the capacity to make informed judgments about when and how AI should be utilized. This distinction is important because AI tools are introduced into schools within existing educational contexts and curricula. Consequently, an educator may design a lesson using an AI tool while still needing to evaluate whether the information it provides is accurate, whether its outputs meet students' learning needs, whether it supports or undermines critical thinking, and how it affects student authorship, privacy, assessment equity, and fairness. These are not secondary considerations; rather, they form an integral part of teacher AI literacy itself (Cabero-Almenara et al., 2025; Chu & Ma, 2026; Rajabi, 2026).

The tensions evident in the pre-service teacher data demonstrate that many prospective teachers recognize the potential value of AI yet remain hesitant to implement it in their classrooms. This hesitancy does not typically indicate a lack of motivation or ability but rather reflects the principles of andragogy in professional development. Professional development becomes more relevant, practical, and effective when it addresses immediate teaching needs, such as lesson planning, feedback, differentiation, academic honesty, and student support, while also drawing on current teaching challenges and learners' past experiences (Knowles et al., 2020).

As such, AI-related teacher preparation should focus primarily on addressing authentic classroom dilemmas rather than simply providing training on AI tools. Although each framework identified in the reviewed literature has its own merits, none provides a comprehensive solution to all aspects of the problem. TPACK explains the relationship between AI use, pedagogical approaches, and subject matter knowledge. TAM and UTAUT explain why educators adopt or reject specific educational technologies. DigCompEdu offers a broader perspective on the competencies required for effective digital teaching.

However, in the classroom context, educators must address all of these aspects simultaneously, including knowledge, intention, ethical considerations, hardware and software infrastructure, and institutional support. Therefore, as illustrated in Figure 1, the competence–constraint–development model is used here as an

organizational lens rather than as a comprehensive theoretical framework. The ethical concerns identified in the reviewed studies also emerged as the most frequently reported barriers. This likely reflects the fact that the earliest applications of generative AI in education were concentrated in sensitive areas such as writing, assessment, grading, feedback, authorship, and student support. These are domains that rely heavily on teachers' professional judgment. Consequently, concerns about plagiarism, bias, misinformation, student privacy, and overreliance on AI represent more than a simple resistance to technological change (Alasgarova & Rzayev, 2025; Aydeniz, 2025; Caling et al., 2025).

Workshops may introduce AI integration, but they cannot resolve challenges such as unclear policies, inadequate infrastructure, assessment ambiguity, workload pressures, or limited leadership support. More sustainable responses should therefore combine professional development with curriculum revision, mentoring, collaborative inquiry, and classroom-based experimentation. The evidence base is also uneven, with higher education being strongly represented, while K-12 settings, rural schools, low-resource institutions, school administrators, and teacher educators remain comparatively underrepresented. This is important because findings derived primarily from university contexts may not transfer readily to school settings with different infrastructure, regulations, parental expectations, and learner needs. In this sense, the review clarifies that AI literacy and teacher readiness are related but distinct constructs, and that teacher preparation should be understood as a situated process shaped by contextual conditions.

Teacher education and professional development programs need to incorporate conceptual understanding, hands-on experimentation, ethical reflection, subject-specific adaptation, and institutional guidance on the appropriate use of AI in the classroom. For research, the next step should involve longitudinal studies that examine how teacher AI literacy develops into teacher readiness over time and identify the institutional conditions under which readiness translates into responsible classroom implementation.

6. Conclusion

This scoping review investigated how the current literature defines teacher AI literacy and teacher readiness for AI-enhanced instruction. The results indicate a field that is rapidly expanding, particularly since the emergence of AI in education, but also one in which overlapping terms continue to be used to describe related yet distinct concepts, including AI literacy, competence, readiness, preparedness, adoption, and acceptance.

In this review, teacher AI literacy is understood as a combination of conceptual knowledge, pedagogical adaptability, ethical awareness, and the ability to critically evaluate AI-generated outputs. Teacher readiness, however, refers more directly to the confidence, support, and professional justification teachers require to implement AI effectively in real classroom settings. Accordingly, the barriers most frequently reported extend beyond access to include ethical uncertainty, limited institutional leadership, inadequate technical infrastructure, assessment

concerns, and insufficient training or professional development. Although workshops may introduce teachers to AI and demonstrate potential classroom applications, exposure alone does not ensure that educators have the knowledge, resources, and institutional conditions necessary to use AI effectively.

Conflict of Interest

The author declares that there are no conflicts of interest regarding the publication of this article.

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