CogNexus
Multilingual, International, Peer-Reviewed, Open Access Journal
Vol. 1(4) 2025, 260-292

Preparing K-12 Teachers for Artificial Intelligence: Teacher Readiness, Professional Development Needs, and AI Integration in American Classrooms

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DOI: https://doi.org/10.63084/cognexus.v1i04.286

Abstract

The rapid expansion of artificial intelligence in education has increased expectations for teachers to integrate AI into instructional practice while addressing concerns related to accuracy, ethics, privacy, academic integrity, and student learning. This study examined AI readiness, professional development needs, institutional support, and classroom AI integration among K-12 teachers in the United States. Data were collected through a cross-sectional survey of 526 practicing teachers representing elementary, middle, and high school settings across U.S. geographic regions. Teacher AI readiness was examined across cognition, ability, vision, and ethics, alongside measures of professional development, institutional support, perceived barriers, and teacher-facing and student-facing AI use. Teachers reported moderate overall AI readiness, with ethical readiness receiving the highest ratings and practical ability the lowest. Although 68.6% of participants reported using AI for professional or instructional purposes, only 41.8% had received formal AI-related professional development. Teachers identified substantial professional development needs, particularly in evaluating AI-generated information, protecting student privacy, identifying bias, assessing AI-generated student work, and establishing appropriate expectations for student AI use. AI readiness was positively associated with classroom AI integration, and readiness emerged as the strongest predictor of integration after accounting for professional development, institutional support, barriers, teaching experience, and instructional level. Institutional support and previous AI-related professional development were also positively associated with classroom integration. The findings suggest that effective AI integration depends not only on access to emerging technologies but also on teachers' practical competence, sustained professional learning, and supportive institutional conditions. Schools, districts, and teacher preparation programs should therefore prioritize comprehensive AI professional development that integrates technological knowledge, pedagogy, ethical judgment, and responsible classroom application.

Keywords: artificial intelligence, teacher readiness, professional development, AI integration, K-12 education, teacher education

Introduction

Artificial intelligence has moved rapidly from a specialized technology operating largely in the background of educational software to an increasingly visible component of everyday teaching and learning. Artificial intelligence systems have long supported functions such as adaptive learning, automated assessment, learning analytics, and personalized feedback, but the emergence of widely accessible generative artificial intelligence tools has substantially expanded the range of tasks that teachers and students can perform with AI. These systems can generate text, images, instructional materials, explanations, assessment items, feedback, and other forms of content in response to natural language prompts. Consequently, the central question facing schools is increasingly not simply whether artificial intelligence will enter classrooms, but how educators can use it in ways that improve teaching and learning while preserving human judgment, student agency, equity, privacy, and educational integrity (Crompton et al., 2024; Miao & Holmes, 2023; U.S. Department of Education, Office of Educational Technology, 2023).

Teachers occupy a particularly important position in this transition. The educational value of AI does not arise automatically from the availability of increasingly capable technologies. Rather, teachers make consequential decisions about whether a particular technology is appropriate, when it should be used, how its outputs should be evaluated, how it should be connected to curricular goals, and when human judgment should override automated recommendations. Research conducted before and during the emergence of generative AI demonstrates that AI can support instructional planning, differentiated learning, assessment, feedback, and access to educational resources, but it can also introduce concerns involving inaccurate information, algorithmic bias, transparency, privacy, accountability, inappropriate reliance on automated systems, and changes in teacher and student agency (Chounta et al., 2022; Crompton et al., 2024; U.S. Department of Education, Office of Educational Technology, 2023). The challenge is therefore pedagogical and organizational as much as technological. Successful AI integration depends in substantial part on whether teachers possess the knowledge, confidence, professional judgment, and institutional support required to make informed decisions about AI in the classroom.

This distinction places teacher readiness at the center of AI integration. Readiness for AI involves more than general familiarity with computers or positive attitudes toward technology. Wang et al. (2023), for example, conceptualized teacher AI readiness through four interconnected dimensions: cognition, ability, vision, and ethical considerations. In their empirical study of 3,164 primary school teachers, higher levels of AI readiness were associated with greater AI supported innovation and greater job satisfaction, while teachers with stronger readiness also tended to perceive lower levels of threat from AI. Similarly, research extending the technological pedagogical content knowledge framework to AI suggests that technological

knowledge alone is insufficient for meaningful classroom implementation. Teachers must be able to connect technological capabilities with pedagogical knowledge and make informed ethical judgments about AI based systems, an approach captured in Celik's (2023) Intelligent TPACK framework. These findings suggest that readiness should be understood as a multidimensional capacity encompassing knowledge of AI, the ability to apply it pedagogically, confidence in making decisions about its use, awareness of its limitations, and the capacity to evaluate its ethical consequences.

The concept of AI literacy further broadens what teachers may need to know. Long and Magerko (2020) conceptualized AI literacy as a collection of competencies that allow individuals to understand, interact with, critically evaluate, and communicate about artificial intelligence. By 2024, UNESCO had translated this broader concern into a teacher specific competency framework consisting of 15 competencies organized across five areas: a human centered mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. The framework further organized these competencies across progressively more advanced levels of acquisition, deepening, and creation (Miao & Cukurova, 2024). This framework is important because it distinguishes AI competence from conventional digital literacy. A teacher may be competent in learning management systems, presentation software, digital communication, or internet based instructional resources without necessarily understanding generative AI, algorithmic decision making, prompt design, hallucination, training data, automated recommendations, or the ethical implications of using AI-generated content with students.

Empirical research supports this distinction. In a 2024 study of 211 primary and secondary teachers, Lucas et al. found positive relationships among teachers' AI knowledge, digital competence, and trust in AI. More importantly, knowledge of AI emerged as a substantial predictor of trust, and the relationship between general digital competence and trust in AI was largely mediated by AI specific knowledge. Earlier research similarly found that K-12 teachers may recognize potential educational benefits from AI while possessing limited knowledge of how the technology operates or how it should be incorporated into practice (Chounta et al., 2022). Collectively, these findings indicate that preparing teachers for AI cannot be reduced to conventional technology training. AI integration requires competencies that combine technological understanding with pedagogy, ethics, professional judgment, and critical evaluation.

The urgency of this issue is particularly evident in the United States. Using a nationally representative sample of 1,020 public school teachers surveyed in fall 2023, Diliberti et al. (2024) found that 18 percent of K-12 teachers reported using AI for teaching and another 15 percent had tried AI at least once. Usage also varied considerably across teaching contexts. Middle and high school teachers were more likely than elementary teachers to use AI, while English language arts and social studies teachers were among the more

frequent users. Among teachers who were using AI, common applications included adapting instructional content to students' needs and generating instructional materials. These findings illustrate that AI adoption was already underway in American schools by the 2023 to 2024 school year, but that it was neither universal nor evenly distributed across educators.

Institutional preparation was similarly uneven. Diliberti et al. (2024) reported that 60 percent of districts expected to have provided teacher training on AI by the end of the 2023 to 2024 school year, while urban districts were among those least likely to report plans for such training. This discrepancy is important because access to a technology does not guarantee the capacity to use it meaningfully. If teachers encounter AI primarily through individual experimentation rather than coherent professional learning, implementation may vary substantially in quality, purpose, and attention to student safety. Such differences can potentially create a new dimension of educational inequality in which some teachers and schools develop sophisticated ways of using AI to design instruction, differentiate learning, and support students, while others have limited opportunities to develop comparable competencies.

Professional development therefore represents a critical mechanism connecting technological availability with meaningful instructional practice. A substantial body of teacher learning research demonstrates that effective professional development is generally content focused, incorporates active learning, supports collaboration, provides models of effective practice, offers coaching or expert support, creates opportunities for feedback and reflection, and extends over sufficient time rather than relying exclusively on isolated workshops (Darling Hammond et al., 2017; Desimone, 2009). These principles are particularly relevant to AI because teachers need opportunities not merely to hear about artificial intelligence but to experiment with AI tools, assess their outputs, identify potential errors and biases, consider appropriate classroom scenarios, design AI supported lessons, and reflect on implications for students.

AI specific research provides further support for this approach. Nazaretsky et al. (2022) found that professional development that helped teachers understand how AI systems make decisions and demonstrated how AI could complement rather than replace teacher expertise could reduce concerns and increase teachers' trust in AI powered educational technologies. Their findings also emphasized the importance of giving teachers practical experience with AI tools and preserving teachers' ability to review, modify, or override AI-generated recommendations. Celik (2023) similarly demonstrated that teachers' ability to integrate AI depends on the combination of technological and pedagogical knowledge and on their capacity to evaluate ethical dimensions of AI based decisions. Professional development for AI should therefore extend beyond procedural instruction in how to operate particular platforms. It should build teachers' capacity to determine why, when, and under what conditions AI contributes to learning.

The need to develop this capacity became an explicit concern of United States education policy before the end of 2024. In *Artificial Intelligence and the Future of Teaching and Learning*, the U.S. Department of Education emphasized that AI should support rather than displace educators and called for human centered approaches that maintain human judgment, address algorithmic bias and fairness, protect students, and involve educators in the design and implementation of AI enabled educational systems (U.S. Department of Education, Office of Educational Technology, 2023). Executive Order 14110, issued in October 2023, subsequently directed the Secretary of Education to develop resources, policies, and guidance concerning safe, responsible, and nondiscriminatory uses of AI in education and specifically called for an AI toolkit for education leaders.

Two major federal education documents released in 2024 further reinforced the importance of educator capacity. The *2024 National Educational Technology Plan* identified a "digital design divide" involving differences between educational systems that provide educators with sufficient time and support to develop their capacity to design learning experiences with technology and systems that do not provide comparable opportunities (U.S. Department of Education, Office of Educational Technology, 2024a). Later that year, the Department released *Empowering Education Leaders: A Toolkit for Safe, Ethical, and Equitable AI Integration*. The toolkit translated earlier federal recommendations into guidance for schools and districts considering AI adoption, emphasizing safe and effective integration, transparency, privacy, human oversight, equitable implementation, and the involvement of teachers and other educational stakeholders in decisions about AI enabled applications (U.S. Department of Education, Office of Educational Technology, 2024b). Together, these federal documents indicate that teacher capacity is not peripheral to the implementation of AI in education. It is a necessary condition for responsible implementation.

Despite these developments, important empirical questions remained unresolved at the end of 2024. Research had established that teachers vary in their knowledge, trust, perceptions, and readiness for AI (Chounta et al., 2022; Lucas et al., 2024; Wang et al., 2023), while national evidence documented substantial differences in whether and how American teachers were using AI and whether their districts intended to provide training (Diliberti et al., 2024). However, these strands of evidence do not by themselves explain how teacher readiness, perceived professional development needs, and actual classroom integration relate to one another within the American K-12 context. Much of the empirical work examining teacher AI readiness and knowledge was conducted outside the United States, while the emerging national U.S. evidence was primarily descriptive of adoption, use, and district activity. Consequently, there remained a need to examine not merely whether teachers were using AI, but whether they felt prepared to use it, what forms of professional learning they believed they needed, and how readiness and professional support

corresponded with the ways AI was being integrated into classroom practice.

Accordingly, the present study examines teacher readiness for artificial intelligence, professional development needs related to AI, and the extent and nature of AI integration in American K-12 classrooms. By examining these dimensions together, the study seeks to provide a more comprehensive picture of the human capacity required for AI enabled educational change. Understanding teachers' readiness can identify areas in which knowledge, confidence, pedagogical competence, or ethical awareness remain underdeveloped. Examining professional development needs can clarify what forms of support educators consider necessary for responsible implementation. Assessing classroom integration can reveal whether AI use is moving beyond experimentation toward purposeful instructional practice. Taken together, these insights can inform teacher preparation programs, school and district professional learning strategies, educational technology policy, and broader efforts to ensure that the adoption of artificial intelligence strengthens rather than undermines equitable, effective, and human centered teaching and learning.

Literature Review

Artificial Intelligence in K-12 Education

Artificial intelligence in education predates the recent emergence of generative artificial intelligence. Earlier applications included intelligent tutoring systems, adaptive learning environments, automated assessment, learning analytics, student monitoring, and systems designed to provide personalized instructional support. These applications generally positioned AI as a mechanism for analyzing learner data, adapting educational content, automating selected tasks, or providing recommendations to teachers and students. Reviews of the K-12 literature indicate that AI has been used to support both student learning and teachers' instructional work, although the nature and maturity of implementation have varied considerably across educational contexts (Crompton & Burke, 2022; Crompton et al., 2024).

Crompton and Burke's (2022) systematic review identified several ways AI had been used to support educators, including student monitoring, group management, automated grading, and data informed instructional decision making. From the student perspective, AI applications included intelligent tutoring, individualized learning experiences, and technologies intended to extend student thinking. Similarly, Crompton et al. (2024), in a systematic review of 169 K-12 studies published between 2011 and 2021, found that AI applications were associated with pedagogical functions, administrative functions, and subject specific learning. The same review identified persistent challenges involving negative perceptions of AI, inadequate teacher and student technological skills, ethical concerns, and problems related to usability and system design. These findings demonstrate that the pedagogical potential of AI has long coexisted with implementation challenges involving users, institutions, and technology.

The arrival of generative AI substantially altered this landscape. Unlike many earlier AI applications that were embedded within specialized educational systems, generative AI tools allow educators to interact directly with AI through natural language. Teachers can potentially use these technologies to generate instructional materials, draft lesson plans, create examples and assessment questions, adapt texts for different learners, formulate feedback, summarize information, and support routine communication. This accessibility lowers some technical barriers to AI use while simultaneously increasing the responsibility placed on teachers to evaluate the accuracy, appropriateness, and educational value of AI-generated outputs.

A 2024 systematic review of AI applications supporting teaching further illustrates this changing relationship. Shi and Choi (2024) reviewed 44 empirical studies and identified three broad pedagogical roles for AI: AI as an instructional partner, an evaluative partner, and a pedagogical decision partner. Their synthesis emphasizes that AI can augment different dimensions of teachers' work rather than functioning solely as a student-facing tutoring technology. At the same time, greater AI autonomy can create concerns about the appropriate division of responsibility between educators and automated systems. The implication is that successful AI integration depends not merely on technological capability but also on teachers' capacity to make informed pedagogical decisions about when and how those capabilities should be used.

This distinction is particularly important because the educational effectiveness of AI cannot be inferred from the sophistication of the technology itself. AI-generated materials may be fluent without being accurate, relevant without being pedagogically appropriate, or efficient without contributing meaningfully to learning. Consequently, teachers remain responsible for aligning AI supported activities with curriculum, learner needs, assessment goals, and standards of professional practice. This places teacher knowledge and readiness at the center of the AI integration process.

Teacher Readiness for Artificial Intelligence

Teacher readiness has historically been an important consideration in the adoption of educational technologies. Research on technology integration has demonstrated that access to technology alone does not ensure meaningful classroom implementation. Teacher knowledge, confidence, beliefs, institutional support, available time, professional learning, and perceptions of usefulness can all influence whether technology becomes incorporated into instructional practice (Hew & Brush, 2007). AI introduces additional requirements because teachers must assess not only how to operate a technology but also the credibility, limitations, transparency, and ethical implications of outputs produced by automated systems.

Wang et al. (2023) provided one of the most comprehensive conceptualizations of teacher AI readiness. They defined readiness through four dimensions: cognition, ability, vision, and ethics. Cognition concerns teachers' understanding and awareness of AI. Ability concerns their capacity to apply AI in professional

practice. Vision captures expectations about the educational possibilities of AI, while ethics concerns the ability to recognize and respond to ethical issues arising from its use. Using data from 3,164 primary school teachers, the authors found that all four dimensions of readiness positively predicted AI enhanced innovation. Teachers with higher levels of AI readiness also perceived lower levels of threat from AI and exhibited greater AI-related innovation.

The multidimensional nature of the construct is important for the present study. A teacher may understand the general concept of AI yet remain unable to incorporate it into a lesson. Another may be proficient in operating an AI application but inadequately prepared to recognize bias, inaccurate outputs, privacy concerns, or inappropriate uses. Still another may possess the necessary skills but lack confidence or perceive little instructional value in the technology. Teacher readiness should therefore not be treated as equivalent to access, general technological proficiency, or frequency of technology use.

Evidence from earlier K-12 research supports this distinction. Chounta et al. (2022) surveyed Estonian K-12 teachers in a national context widely recognized for technological innovation. Although participants generally viewed AI as potentially beneficial for education, most characterized their knowledge of AI as limited or basic. Teachers were interested in AI applications that could assist with activities such as accessing, adapting, and using learning materials, but their responses also indicated a need for greater support and understanding. Thus, even teachers functioning in a technologically advanced educational environment may possess general digital experience without corresponding AI specific knowledge.

This distinction became more consequential with generative AI because teachers could gain immediate access to powerful applications without receiving formal training in how those systems work. Readiness in the generative AI era therefore involves the capacity to use AI as well as the judgment required to determine when it should not be used. This includes recognizing limitations, checking generated information, maintaining appropriate human oversight, protecting students, and ensuring that instructional use remains connected to learning objectives.

AI Literacy and Teachers' Professional Knowledge

The literature on AI literacy provides a related foundation for understanding teacher readiness. Long and Magerko (2020) defined AI literacy through competencies that enable individuals to critically evaluate AI technologies, communicate and collaborate effectively with AI, and use AI as a tool. Their framework helped shift discussions of AI competence away from the assumption that AI literacy requires advanced programming expertise. Instead, users need conceptual and evaluative capacities that allow them to interact intelligently with AI systems.

For teachers, however, general AI literacy is not sufficient. Educators must translate AI knowledge into

decisions about curriculum, pedagogy, assessment, classroom management, differentiation, and student development. Celik (2023) addressed this requirement through an extension of the technological pedagogical content knowledge framework. The resulting Intelligent TPACK perspective emphasizes teachers' technological and pedagogical knowledge concerning AI together with their ability to evaluate AI-related decisions ethically. Celik found that technological knowledge by itself was insufficient for effective educational integration. The combination of technological and pedagogical knowledge was particularly important, supporting the proposition that effective AI use requires teachers to understand how technological affordances relate to instructional goals.

This finding is consistent with broader research on educational technology. Technology integration becomes instructionally meaningful when teachers can connect technological capabilities to teaching strategies and disciplinary objectives. AI magnifies this issue because the same application may support productive learning in one context while weakening learning in another. For example, using generative AI to produce differentiated examples for a teacher may serve a different pedagogical purpose from allowing students to generate complete answers to an assignment designed to develop independent reasoning. Competence therefore includes the ability to evaluate the interaction between the tool, the learner, the task, and the intended educational outcome.

Lucas et al. (2024) further demonstrated that AI specific knowledge cannot simply be substituted with general digital competence. In a study of 211 primary and secondary teachers, the authors examined relationships among digital competence, knowledge of AI, and trust in AI. All three variables were positively related, but knowledge of AI emerged as a particularly important predictor of trust. When AI knowledge was removed from the relationship between digital competence and trust, the relationship between the latter variables was no longer significant. The results indicate that being generally capable with digital technologies does not necessarily provide teachers with the knowledge necessary to evaluate AI.

By 2024, the emerging literature on teacher AI competence had become sufficiently developed for UNESCO to publish its *AI Competency Framework for Teachers*. The framework identifies 15 competencies across five dimensions: human centered mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. It also organizes teacher development into acquisition, deepening, and creation stages. The framework reinforces the view that teacher AI competence includes knowledge, values, pedagogical application, ethical responsibility, and continued professional learning rather than merely operational skill (Miao & Cukurova, 2024).

Taken together, this literature indicates that teacher readiness for AI should incorporate AI specific knowledge, pedagogical capability, confidence, ethical awareness, and an understanding of the appropriate

boundaries of AI use. These dimensions provide an important foundation for examining whether teachers feel prepared to integrate AI into American K-12 classrooms.

Teacher Trust, Attitudes, and Perceived Risks

Knowledge and competence alone may not determine whether teachers adopt AI. Teachers must also decide whether AI systems are trustworthy enough to be incorporated into professional practice. Trust becomes particularly important when technologies produce recommendations, classifications, assessments, or content that would otherwise rely on human judgment.

Nazaretsky et al. (2022) examined K-12 science teachers' trust in AI powered educational technology through a professional development intervention involving an AI based assessment system. Their findings showed that teachers' concerns could be reduced when they received explanations of how the AI system made decisions and how its performance related to human judgment. Teachers also responded more positively when AI was presented as a technology that could complement teacher expertise rather than replace it. The study consequently linked greater AI knowledge with increased trust and willingness to adopt AI enabled educational tools.

Importantly, the authors emphasized teacher agency. AI applications were viewed more favorably when teachers retained the ability to inspect, modify, or override automated recommendations. This suggests that trust does not require unquestioning acceptance of AI. Appropriate professional trust may instead depend on teachers understanding the limits of a system while maintaining authority over educational decisions.

Lucas et al. (2024) provide additional empirical support for the importance of AI knowledge to trust. Their finding that AI knowledge was a substantial predictor of teachers' trust indicates that professional development may influence adoption partly by reducing uncertainty about what AI is and how it functions. This connection is particularly important because both excessive distrust and excessive trust can be problematic. Teachers who categorically reject AI may forego potentially useful instructional applications, whereas teachers who trust AI outputs without adequate scrutiny may expose students to misinformation, bias, or inappropriate automated decision making.

Teachers' attitudes are also shaped by perceived educational benefits and risks. Chounta et al. (2022) found that teachers could simultaneously possess limited knowledge of AI and perceive opportunities for its use. More recent generative AI research similarly suggests that teachers frequently express a mixture of optimism and concern. Kokoç (2024), using qualitative interviews with secondary school teachers, identified perceived opportunities associated with generative AI alongside concerns about inaccurate or biased outputs, technological infrastructure, and insufficient training. The study concluded that supportive educational programs and stronger technological infrastructure were important for effective adoption.

These findings suggest that readiness and attitudes are not opposing explanations for AI use. Greater knowledge may shape perceptions of usefulness, risk, and trust, which may subsequently influence whether teachers experiment with or integrate AI. A comprehensive assessment of readiness should therefore consider both competence and teachers' perceptions of the technology.

Professional Development for AI Integration

Professional development is one of the principal mechanisms through which teachers acquire the knowledge and capabilities required to implement new instructional practices. The broader teacher learning literature provides substantial guidance about characteristics associated with effective professional development. Desimone (2009) identified core features such as content focus, active learning, coherence, duration, and collective participation. Darling Hammond et al. (2017), reviewing 35 methodologically rigorous studies, similarly identified content focus, active learning, collaboration, models of effective practice, coaching and expert support, feedback and reflection, and sustained duration as common characteristics of effective professional learning.

These principles have direct implications for AI preparation. A short demonstration of an AI application may increase awareness without developing teachers' ability to evaluate outputs, design AI supported learning activities, or respond to ethical challenges. Effective AI professional development is likely to require opportunities for teachers to interact with actual tools, analyze examples, identify errors, compare AI-generated and human generated work, redesign instructional activities, discuss ethical scenarios, and receive feedback about implementation.

Nazaretsky et al. (2022) provide empirical evidence for this approach. Their professional development program combined conceptual explanations of AI with practical engagement involving an AI powered assessment application. Participants developed greater knowledge of the technology and expressed increased willingness to use it. The authors recommended that professional development focus on concrete pedagogical tasks, relevant AI tools, basic understanding of AI mechanisms, and preservation of teacher agency.

The 2024 UNESCO framework similarly treats professional learning as a continuing component of teacher AI competence rather than a single training event. Its progression from acquisition to deepening and creation implies that teachers may move from basic understanding toward increasingly sophisticated pedagogical and professional uses of AI (Miao & Cukurova, 2024).

Professional development needs may also differ across teachers. Educators who have never used generative AI may need foundational instruction concerning terminology, capabilities, limitations, and responsible use. Teachers already experimenting with AI may instead need advanced support for instructional design,

assessment, differentiation, or evaluation of AI outputs. Professional learning strategies that treat all teachers as possessing the same starting knowledge may therefore fail to address meaningful differences in readiness.

AI Integration in American K-12 Classrooms

Although much of the early empirical research on teacher AI readiness originated outside the United States, evidence available by 2024 indicated that AI was already entering American classrooms. Diliberti et al. (2024) surveyed a nationally representative sample of 1,020 U.S. public school teachers in fall 2023. Eighteen percent were classified as AI users in their teaching, while another 15 percent had tried AI tools at least once. Sixty six percent were classified as nonusers. Among teachers using AI, common purposes included adapting instructional content to student needs and generating educational materials. Adoption also varied by grade level and subject, with middle and high school educators and teachers in English language arts and social studies more likely to report using AI than some other groups.

These results are important for two reasons. First, they demonstrate that AI integration was already occurring in U.S. schools shortly after the rapid expansion of generative AI. Second, adoption was uneven. The existence of substantial variation raises questions about what differentiates teachers who use AI from those who do not. Differences may reflect knowledge, confidence, perceived utility, professional development, institutional support, availability of technology, teaching context, or combinations of these factors.

The organizational environment also appears consequential. Diliberti et al. (2024) found that 60 percent of districts expected to have trained teachers about AI by the end of the 2023 to 2024 school year. However, training availability was not uniform, and urban districts were among those less likely to report plans for AI training. Such differences create the possibility that teacher preparation for AI may depend partly on where an educator works rather than solely on individual motivation or competence.

Additional U.S. evidence reinforces the importance of institutional support. Sanders et al. (2024) surveyed 1,000 K-12 educators across U.S. states and territories between January and May 2024. Seventy eight percent agreed that recently developed AI tools could help address important classroom challenges. At the same time, 53 percent did not feel confident in their ability to use AI tools in the classroom, although 79 percent felt confident that they could learn to use them. Ninety percent indicated that it was important for schools to provide greater support for teachers learning to use new AI tools. Statistical analyses further indicated that institutional support and time to learn were associated with teachers' confidence and likelihood of using AI.

This distinction between confidence in current ability and confidence in the ability to learn is particularly

significant. It suggests that low readiness should not automatically be interpreted as teacher resistance. Teachers may be open to AI while lacking the training, time, policies, or institutional conditions necessary to implement it. Professional development and organizational support therefore have the potential to convert willingness into meaningful instructional capability.

Smaller U.S. studies also suggest that familiarity matters. Doty and Lipien (2024), examining online K-12 teachers at a virtual school on the East Coast of the United States, found that teacher familiarity with AI was related to adoption of AI tools. Although the context limits broad generalization, the result is consistent with the broader proposition that knowledge and experience contribute to classroom integration.

Ethical and Responsible AI Integration

Teacher preparation for AI must also include responsible use. AI applications may raise concerns related to privacy, data security, algorithmic bias, transparency, misinformation, academic integrity, student autonomy, equitable access, and the appropriate role of automated systems in educational decision making. Akgun and Greenhow (2022) argued that the ethical and societal consequences of AI require explicit attention in K-12 settings. They identified the need for educators and students to understand ethical issues associated with AI systems rather than focusing exclusively on technological capabilities. Their analysis demonstrates that AI literacy in schools necessarily has an ethical dimension because decisions about data, algorithms, and automated recommendations can affect students differently.

The U.S. Department of Education's 2023 report on AI and the future of teaching and learning similarly emphasized human centered use of AI, preservation of human judgment, attention to bias, and the need for educators to remain involved in decisions concerning AI enabled educational technologies. The report positioned AI as potentially supportive of teaching while rejecting the assumption that automation should replace educators' professional judgment (U.S. Department of Education, Office of Educational Technology, 2023).

The ethical dimension is particularly consequential in K-12 education because schools serve minors and because educational decisions can influence academic opportunity and development. Teachers must therefore be prepared not only to determine whether an AI tool functions, but whether its use is appropriate for a particular student population, task, and educational objective.

Ethical competence consequently forms part of teacher readiness rather than representing a separate concern. Wang et al. (2023) incorporated ethics directly into their four dimensional model of AI readiness, Celik (2023) incorporated ethical assessment into Intelligent TPACK, and UNESCO's 2024 teacher competency framework identifies ethics of AI as one of its five principal competency dimensions. Across these perspectives, responsible integration requires teachers capable of combining technological

knowledge, pedagogical judgment, and ethical reasoning.

Synthesis and Research Gap

The literature through 2024 establishes several important conclusions. First, AI has substantial potential to support instruction, assessment, differentiation, administrative work, and pedagogical decision making, but these benefits are contingent on the ways educators employ the technology (Crompton & Burke, 2022; Crompton et al., 2024; Shi & Choi, 2024). Second, teacher AI readiness is multidimensional and includes knowledge, ability, perceptions of AI's educational possibilities, and ethical competence (Wang et al., 2023). Third, general digital competence cannot be assumed to equal AI competence. AI specific knowledge appears particularly important for teachers' trust and capacity to evaluate AI technologies (Lucas et al., 2024). Fourth, professional development can improve knowledge and trust when it allows teachers to develop conceptual understanding while engaging with concrete pedagogical applications (Nazaretsky et al., 2022). Finally, emerging U.S. evidence demonstrates considerable variation in classroom adoption and substantial teacher demand for additional institutional support and professional learning (Diliberti et al., 2024; Sanders et al., 2024).

Important gaps nevertheless remained at the close of 2024. Much of the empirical literature specifically measuring teacher AI readiness had been conducted outside the United States. For example, Chounta et al. (2022) studied teachers in Estonia, Wang et al. (2023) examined primary school teachers in China, and Lucas et al. (2024) examined primary and secondary teachers in a non U.S. context. These studies provide important theoretical and empirical foundations, but national and institutional differences limit the extent to which their findings can automatically be generalized to American K-12 education.

Conversely, the strongest national U.S. studies available by 2024 primarily documented rates of adoption, teacher perceptions, district training, and institutional support. RAND provided nationally representative evidence about who was using AI and how it was being used, while Sanders et al. (2024) provided substantial evidence concerning confidence, perceived usefulness, concerns, and school support. These studies establish the emerging landscape but leave room for a more integrated investigation of the relationships among teacher readiness, professional development needs, and actual classroom integration.

A further gap concerns the relationship between professional development and readiness. Existing research indicates that professional learning can increase AI knowledge and trust and that teachers desire greater institutional support, yet it remains necessary to determine the specific areas in which American K-12 teachers perceive themselves as insufficiently prepared and the forms of professional development they believe would best support instructional implementation.

Accordingly, the present study addresses these gaps by examining three related dimensions within the same

investigation: teachers' readiness for artificial intelligence, their perceived professional development needs, and their integration of AI into classroom practice in the United States. Examining these constructs together makes it possible to move beyond describing whether teachers use AI toward explaining the professional capacities and institutional supports associated with meaningful adoption. Such evidence can contribute to the design of teacher preparation, professional development, district implementation strategies, and policies intended to support responsible AI integration in American K-12 education.

Research Questions

RQ1. What levels and dimensional patterns of AI readiness are reported by K-12 teachers?

RQ2. What AI-related professional development needs do K-12 teachers report, and how do perceived needs differ according to prior formal AI professional development?

RQ3. What patterns of teacher-facing and student-facing AI integration are reported, and does overall integration differ by instructional level?

RQ4. How are AI readiness, professional development needs, institutional support, perceived barriers, and classroom AI integration related?

RQ5. Does AI readiness predict classroom AI integration after accounting for prior AI professional development, institutional support, perceived barriers, teaching experience, and instructional level?

RQ6. Which dimensions of AI readiness have the strongest independent associations with classroom AI integration?

Method

Research Design

The study employed a cross-sectional survey design to examine teacher readiness for artificial intelligence, professional development needs, and AI integration among K-12 teachers in the United States. A survey design was appropriate because the study sought to examine variation in teachers' knowledge, perceptions, experiences, and instructional practices across a geographically and professionally diverse population. Previous studies examining teachers' perceptions, knowledge, and readiness for artificial intelligence have similarly relied on survey-based approaches to investigate relationships among AI knowledge, competence, trust, attitudes, and educational use (Chounta et al., 2022; Lucas et al., 2024; Wang et al., 2023).

The study conceptualized AI readiness as a multidimensional construct rather than as general technological competence or prior experience with AI. This distinction reflects evidence that teachers' AI specific knowledge is not interchangeable with broader digital competence. Lucas et al. (2024), for example, found that AI knowledge was strongly associated with teachers' trust in AI and played an important role in the relationship between digital competence and AI trust. Similarly, Celik (2023) demonstrated that

technological knowledge alone was insufficient for the pedagogically and ethically appropriate integration of AI. Accordingly, the present study distinguished teachers' readiness to use AI from their actual classroom use of AI.

The survey also included open-ended questions that allowed teachers to describe perceived barriers to AI integration and the professional support they considered necessary. These responses supplemented the quantitative measures by providing contextual explanations for patterns observed in teacher readiness, professional development, and classroom integration.

Participants

A total of 584 teachers initially accessed the survey. After screening for eligibility and data quality, 526 responses were retained for analysis, representing a retention rate of 90.1% among respondents who initiated the questionnaire. Fifty eight cases were excluded because respondents did not meet eligibility requirements, submitted substantially incomplete questionnaires, failed embedded attention checks, or exhibited response patterns indicative of insufficient engagement.

The final sample consisted of 526 practicing K-12 teachers employed in schools across the United States. Participants reported an average of 11.7 years of teaching experience (SD = 7.8), with experience ranging from less than 1 year to 36 years. The mean age of participants was 39.6 years (SD = 10.4).

Approximately 36.5% of participants taught primarily at the elementary level, 27.8% taught at the middle school level, and 35.7% taught at the high school level. Public school teachers accounted for 79.5% of the sample, while 11.8% worked in public charter schools and 8.7% worked in private schools.

The geographic distribution of the sample included 18.8% of teachers from the Northeast, 21.9% from the Midwest, 37.1% from the South, and 22.2% from the West. In terms of school setting, 27.6% of participants described their schools as urban, 38.2% as suburban, 12.4% as located in towns, and 21.8% as rural.

Participants represented a broad range of instructional areas. Approximately 21.7% primarily taught English language arts or reading, 18.4% mathematics, 15.6% science, 13.1% social studies, 9.7% special education, and 21.5% other instructional areas, including career and technical education, arts, world languages, physical education, and elementary general education.

Regarding educational attainment, 39.4% held a bachelor's degree as their highest qualification, 52.1% held a master's degree, and 8.5% held a specialist or doctoral degree.

Previous experience with artificial intelligence varied substantially. Approximately 68.6% of participants reported having used at least one generative AI application for a professional or instructional purpose, while 31.4% reported no prior instructional use. Among AI users, 42.3% reported using AI at least weekly and 17.9% reported using it several times per week or more frequently. Formal AI-related professional

development had been completed by 41.8% of participants.

Teachers who had not previously used AI were retained because nonuse constituted an important dimension of AI adoption. Prior research demonstrates substantial variation in teachers' exposure to, knowledge of, and use of AI technologies (Chounta et al., 2022; Diliberti et al., 2024). Restricting participation to current AI users would therefore have excluded teachers whose limited readiness, institutional restrictions, lack of training, or concerns about AI potentially explained their nonuse.

Measures

The survey assessed teacher AI readiness, classroom AI integration, previous professional development, perceived professional development needs, institutional support, barriers to AI use, and teacher and school characteristics. Established constructs and findings from previous research informed the development and adaptation of the measures (Celik, 2023; Lucas et al., 2024; Wang et al., 2023).

Teacher AI Readiness

Teacher AI readiness was measured using the conceptual framework developed by Wang et al. (2023), which conceptualizes readiness through cognition, ability, vision, and ethics. Cognition represented teachers' knowledge and understanding of artificial intelligence and its educational applications. Ability reflected teachers' perceived capacity to use AI appropriately in teaching and other professional activities. Vision represented teachers' perceptions regarding the future role of AI in education, while ethics reflected awareness of ethical responsibilities and potential consequences associated with AI use.

The instrument contained 18 items rated on a five-point Likert type scale ranging from 1, strongly disagree, to 5, strongly agree. Minor wording adaptations were made to reflect terminology commonly used in the U.S. K-12 educational context while retaining the conceptual meaning of the original items.

The overall AI readiness measure demonstrated strong internal consistency in the study sample, with Cronbach's alpha of .92 and McDonald's omega of .93. Reliability was also acceptable for cognition (α = .86), ability (α = .89), vision (α = .84), and ethics (α = .88).

Classroom AI Integration

Classroom AI integration was measured as the frequency and breadth with which teachers intentionally used AI for professional and instructional purposes. Items were informed by previous research examining AI use among K-12 teachers, including Diliberti et al. (2024).

Teachers reported how frequently they used AI for lesson planning, developing instructional materials, adapting materials for different learners, generating examples and explanations, preparing assessments, providing feedback, supporting grading, differentiating instruction, communicating with students or families, and completing other teaching related activities. Responses ranged from 1, never, to 5, very

frequently.

The resulting 12 item AI Integration Scale demonstrated high internal consistency (α = .91, ω = .92). The average classroom integration score in the study sample was 2.84 (SD = 0.89).

Teacher-facing and student-facing applications were also examined separately. Teacher-facing AI use was more common, with a mean score of 3.02 (SD = 0.94), compared with a mean of 2.41 (SD = 1.01) for student-facing integration.

AI Related Professional Development

Participants reported whether they had received formal training or professional development concerning artificial intelligence in education. Of the 526 teachers, 220 participants, representing 41.8% of the sample, reported receiving some form of structured AI-related professional development.

Among those who had participated in professional development, 48.6% received training through their school district, 21.4% through their individual school, 12.7% through a professional association, 8.6% through a university or college, and 8.7% through another organization.

The median reported duration of previous AI training was 4 hours. Approximately 62.3% of trained teachers reported that their professional development included hands-on experience with AI applications, while 49.1% reported receiving explicit training related to ethical or responsible AI use.

This distinction between exposure and applied professional learning was informed by Nazaretsky et al. (2022), who demonstrated that professional development addressing teachers' understanding of AI and its application to educational tasks could influence trust and willingness to use AI technologies.

Professional Development Needs

Teachers rated their need for additional preparation across several areas of AI-related professional practice. The resulting 16 item Professional Development Needs Scale demonstrated strong internal consistency (α = .94, ω = .94).

The average professional development need score was 3.67 (SD = 0.76) on a five-point scale, indicating that teachers generally perceived a moderate to high need for additional AI preparation.

The highest rated areas of need were evaluating the accuracy of AI-generated information (M = 4.11, SD = 0.91), protecting student privacy and data (M = 4.05, SD = 0.96), identifying bias and fairness concerns (M = 3.98, SD = 0.93), evaluating AI-generated student work (M = 3.94, SD = 1.01), and establishing appropriate classroom expectations for student AI use (M = 3.90, SD = 0.99).

Teachers reported comparatively lower, although still substantial, professional development needs related to basic prompting strategies (M = 3.28, SD = 1.08) and basic awareness of generative AI tools (M = 3.14, SD = 1.12).

Institutional Support

Institutional support was assessed using 10 items addressing access to AI technologies, availability of technical support, professional development opportunities, clarity of institutional policies, leadership support, collegial collaboration, and time to learn about AI.

The scale demonstrated good internal consistency ($\alpha = .88$, $\omega = .89$). The mean institutional support score was 2.96 (SD = 0.82), suggesting considerable variation in the extent to which teachers perceived their schools and districts as prepared to support AI integration.

Approximately 44.7% of teachers reported that their school or district had established formal guidance concerning teacher use of AI, while 39.2% reported formal guidance concerning student use. Approximately 31.6% indicated that they were unsure whether formal AI policies existed in their schools or districts.

Barriers to AI Integration

Teachers rated potential barriers to AI integration using a five-point scale ranging from not a barrier to a very substantial barrier. The 13 item barrier measure demonstrated strong internal consistency ($\alpha = .90$).

The most frequently reported barriers were concerns regarding the accuracy of AI-generated information (M = 3.88, SD = 0.93), insufficient professional development (M = 3.76, SD = 1.02), uncertainty regarding student academic integrity (M = 3.74, SD = 1.06), lack of time to learn about AI (M = 3.68, SD = 1.01), and unclear school or district policies (M = 3.61, SD = 1.09).

Instrument Development and Validation

The questionnaire underwent expert review, cognitive testing, and pilot administration before the primary survey. The scale development and adaptation process was informed by recommendations emphasizing content validity, cognitive pretesting, evaluation of dimensionality, and reliability assessment when measures are applied to new populations (Boateng et al., 2018).

The initial questionnaire was reviewed by five individuals with expertise in educational technology, teacher education, K-12 instruction, quantitative research methods, and artificial intelligence. Revisions were made to improve clarity and reduce overlap among items.

Cognitive interviews were subsequently conducted with 10 practicing K-12 teachers representing elementary, middle, and high school settings. Feedback primarily resulted in clarification of terminology related to generative AI, AI-generated content, and institutional AI policies.

The revised questionnaire was pilot tested with 52 K-12 teachers who were not included in the final analytical sample. Median completion time during the pilot was 16.8 minutes. Examination of item distributions, missing responses, internal consistency, and participant feedback resulted in minor wording

changes before full administration.

Procedure

Institutional Review Board approval was obtained before recruitment and data collection. Potential participants first completed screening questions confirming that they were currently employed as K-12 teachers in the United States and had direct instructional responsibilities.

Eligible participants reviewed an electronic informed consent statement explaining the study purpose, voluntary nature of participation, confidentiality protections, and their right to discontinue participation. Respondents who provided consent proceeded to the questionnaire.

The survey was administered through a secure electronic survey platform. The median completion time for the final sample was 16.3 minutes. Participants recruited through the research panel received compensation in accordance with the panel provider's standard procedures.

No student names, student educational records, or other personally identifiable student information were collected.

Data Analysis

After data screening, descriptive statistics were calculated to characterize the sample and summarize AI readiness, professional development, institutional support, perceived barriers, and classroom AI integration. Confirmatory factor analysis was conducted to evaluate the four dimensional teacher AI readiness structure proposed by Wang et al. (2023). The four factor model demonstrated acceptable fit to the observed data, $\chi^2(129) = 286.47$, $p < .001$, comparative fit index = .956, Tucker Lewis index = .947, root mean square error of approximation = .048, 90% CI [.041, .055], and standardized root mean square residual = .043. These results supported retention of cognition, ability, vision, and ethics as related but distinguishable dimensions. Bivariate correlations were subsequently examined among the principal variables. Overall AI readiness was positively associated with classroom AI integration, $r = .54$, $p < .001$, and institutional support, $r = .38$, $p < .001$. Professional development participation was also associated with higher readiness and greater classroom AI use.

Multiple regression analysis was used to examine classroom AI integration as a function of overall AI readiness, institutional support, previous formal AI-related professional development, perceived barriers, teaching experience, and instructional level. Previous professional development was coded dichotomously, and elementary school served as the reference category for instructional level. This specification was used consistently in the Results and Table 3.

The primary regression model was evaluated using the overall F test, R^2, adjusted R^2, standardized regression coefficients, and predictor-level significance tests. Because the design was cross-sectional,

regression coefficients were interpreted as adjusted associations rather than causal effects.

Open-ended responses were analyzed using qualitative content analysis. Of the 526 participants, 437 provided at least one substantive written response. Responses were reviewed for recurrent ideas related to AI accuracy, school policy, student dependence, time for professional learning, privacy and ethics, and desired forms of training. Because a single response could express more than one idea, coding categories were not mutually exclusive and theme frequencies were calculated accordingly. The qualitative findings were used to contextualize, rather than replace, the quantitative analyses.

Results

Preliminary Analyses and Sample Characteristics

A total of 584 respondents initiated the survey. Following eligibility screening and data quality assessment, 58 responses were excluded because of ineligibility, substantial missing data, failed attention checks, duplicate participation, or evidence of insufficient engagement. The final analytical sample therefore consisted of 526 K-12 teachers, representing a retention rate of 90.1% among respondents who initiated the survey.

Participants had an average of 11.7 years of teaching experience (SD = 7.8) and a mean age of 39.6 years (SD = 10.4). Elementary school teachers represented 36.5% of the sample, middle school teachers represented 27.8%, and high school teachers represented 35.7%. Most participants were employed in public schools (79.5%), followed by public charter schools (11.8%) and private schools (8.7%). Geographically, 18.8% of respondents were located in the Northeast, 21.9% in the Midwest, 37.1% in the South, and 22.2% in the West.

Of the 526 teachers, 361 (68.6%) reported having used at least one AI application for an instructional or professional purpose, whereas 165 (31.4%) reported no previous instructional use of AI. Formal AI-related professional development had been completed by 220 teachers (41.8%), while 306 teachers (58.2%) reported that they had not received formal professional development related to AI.

Measurement Properties

Confirmatory factor analysis was conducted to examine the factorial structure of the Teacher AI Readiness Scale. The hypothesized four factor model, consisting of cognition, ability, vision, and ethics, provided a good fit to the data, $\chi^2(129) = 286.47$, $p < .001$, CFI = .956, TLI = .947, RMSEA = .048, 90% CI [.041, .055], and SRMR = .043. Standardized factor loadings ranged from .64 to .87, and all loadings were statistically significant at $p < .001$.

The four factor model provided a substantially better representation of the data than a single factor model,

$\chi^2(135) = 612.84$, $p < .001$, CFI = .861, TLI = .842, RMSEA = .082, and SRMR = .071. The improvement in model fit supported treatment of cognition, ability, vision, and ethics as related but distinguishable dimensions of teacher AI readiness.

Internal consistency was high for the overall readiness measure ($\alpha = .92$, $\omega = .93$). Reliability was also satisfactory for cognition ($\alpha = .86$), ability ($\alpha = .89$), vision ($\alpha = .84$), and ethics ($\alpha = .88$). The Classroom AI Integration Scale demonstrated high internal consistency ($\alpha = .91$, $\omega = .92$), as did the Professional Development Needs Scale ($\alpha = .94$, $\omega = .94$). Institutional support also demonstrated satisfactory reliability ($\alpha = .88$, $\omega = .89$), while the perceived barriers measure had an alpha coefficient of .90.

Teacher AI Readiness

Teachers reported a moderate overall level of readiness for artificial intelligence (M = 3.58, SD = 0.62) on the five-point scale. Considerable variation was evident across the four dimensions of readiness.

Ethical readiness received the highest mean rating (M = 4.02, SD = 0.65), indicating relatively strong awareness of ethical considerations associated with AI use. Vision was the second highest dimension (M = 3.76, SD = 0.68), suggesting that teachers generally recognized the potential significance of AI for the future of education.

Cognition received a mean score of 3.44 (SD = 0.71), while ability received the lowest mean score (M = 3.21, SD = 0.79). Thus, although teachers generally expressed awareness of AI and recognized its educational and ethical significance, they reported less confidence in their practical ability to integrate AI into professional and instructional activities.

Table 1

Teacher AI Readiness Descriptive Statistics

AI readiness dimension	M	SD	α
Cognition	3.44	0.71	.86
Ability	3.21	0.79	.89
Vision	3.76	0.68	.84
Ethics	4.02	0.65	.88
Overall AI readiness	3.58	0.62	.92

Teachers who had received formal AI-related professional development reported significantly higher overall readiness (M = 3.75, SD = 0.56) than teachers who had not received formal AI training (M = 3.46, SD = 0.63), $t(524) = 5.56$, $p < .001$, Cohen's d = 0.48. The difference represented a moderate effect and was particularly evident for the ability and cognition dimensions.

Professional Development Needs

Despite generally positive perceptions of AI, teachers reported substantial unmet professional development needs. The overall Professional Development Needs Scale had a mean of 3.67 (SD = 0.76), indicating a moderate to high perceived need for additional preparation.

The greatest need concerned evaluating the accuracy of AI-generated information (M = 4.11, SD = 0.91). Teachers also reported substantial needs related to student privacy and data protection (M = 4.05, SD = 0.96), identifying bias and fairness concerns (M = 3.98, SD = 0.93), evaluating AI-generated student work (M = 3.94, SD = 1.01), and establishing appropriate expectations for student use of AI (M = 3.90, SD = 0.99).

Professional development needs were somewhat lower for basic prompting techniques (M = 3.28, SD = 1.08) and basic awareness of generative AI applications (M = 3.14, SD = 1.12). The pattern suggests that teachers' perceived needs extended beyond learning how to operate AI applications and were concentrated particularly in areas involving evaluation, classroom governance, privacy, ethics, and appropriate instructional use.

Teachers with previous formal AI professional development reported lower unmet professional development needs (M = 3.48, SD = 0.72) than teachers without formal training (M = 3.81, SD = 0.75), $t(524) = 5.05$, $p < .001$, $d = 0.45$. However, even among teachers who had previously received training, mean professional development need remained above the midpoint of the scale.

Classroom AI Integration

The mean classroom AI integration score was 2.84 (SD = 0.89), indicating that AI use was present but had not become a routine component of instructional practice for many teachers.

Teacher-facing AI integration was more common than student-facing integration. Teachers reported a mean teacher-facing integration score of 3.02 (SD = 0.94), compared with 2.41 (SD = 1.01) for student-facing AI integration. The difference was statistically significant, $t(525) = 12.73$, $p < .001$, $d = 0.56$.

Among individual applications, lesson planning, instructional material development, and generation of examples or explanations were among the most frequently reported uses of AI. Direct student interaction with AI, AI assisted grading, and AI supported communication with families were less common.

Teachers who had received formal AI-related professional development reported substantially greater classroom integration (M = 3.22, SD = 0.78) than teachers who had not received formal AI training (M = 2.56, SD = 0.86), $t(524) = 9.17$, $p < .001$, $d = 0.80$. This represented one of the largest group differences observed in the study.

AI integration also varied by instructional level. Elementary school teachers reported the lowest mean

integration score (M = 2.62, SD = 0.85), followed by middle school teachers (M = 2.89, SD = 0.87) and high school teachers (M = 3.04, SD = 0.88). The overall difference was statistically significant, $F(2, 523) = 11.43$, $p < .001$, $\eta^2 = .042$. Post hoc comparisons indicated that elementary teachers reported significantly lower AI integration than both middle and high school teachers. The difference between middle and high school teachers was not statistically significant.

Institutional Support and Barriers

The mean institutional support score was 2.96 (SD = 0.82), indicating substantial differences in the extent to which teachers perceived their schools and districts as prepared to support AI integration.

Approximately 44.7% of participants reported that their school or district had formal guidance concerning teacher use of AI. Formal guidance regarding student use was reported by 39.2% of participants. A substantial proportion of teachers indicated either that no formal guidance existed or that they were uncertain whether their institution had adopted an AI policy.

Teachers identified several important barriers to classroom implementation. Concerns regarding the accuracy of AI-generated information received the highest mean barrier rating (M = 3.88, SD = 0.93), followed by insufficient professional development (M = 3.76, SD = 1.02), concerns regarding student academic integrity (M = 3.74, SD = 1.06), insufficient time to learn about AI (M = 3.68, SD = 1.01), and unclear school or district policies (M = 3.61, SD = 1.09).

These findings indicated that barriers were not limited to teachers' technological skills. Institutional guidance, professional learning opportunities, available time, and uncertainty about responsible student use were also prominent features of teachers' experiences.

Relationships Among AI Readiness, Professional Development Needs, Institutional Support, and AI Integration

Bivariate correlations revealed significant relationships among the principal study variables. Overall AI readiness was positively associated with classroom AI integration, $r = .54$, $p < .001$. Teachers who reported greater readiness therefore tended to report more extensive use of AI in their instructional practice.

Institutional support was positively associated with both AI readiness, $r = .38$, $p < .001$, and classroom AI integration, $r = .44$, $p < .001$. Professional development needs were negatively associated with AI readiness, $r = -.42$, $p < .001$, indicating that teachers who reported greater readiness generally perceived fewer unmet training needs.

Perceived barriers were negatively associated with classroom AI integration, $r = -.31$, $p < .001$, and AI readiness, $r = -.27$, $p < .001$. Barriers were positively associated with professional development needs, $r = .46$, $p < .001$.

Table 2 Correlations Among Principal Study Variables

Variable	1	2	3	4	5
1. AI readiness	1				
2. AI integration	.54***	1			
3. Professional development needs	-.42***	-.18***	1		
4. Institutional support	.38***	.44***	-.29***	1	
5. Perceived barriers	-.27***	-.31***	.46***	-.35***	1

Note. ***$p < .001$.

Predictors of Classroom AI Integration

A multiple regression analysis was conducted to examine whether teacher AI readiness was associated with classroom integration after accounting for professional development, institutional support, perceived barriers, teaching experience, and instructional level.

The overall model was statistically significant, $F(7, 518) = 49.33$, $p < .001$, and explained approximately 40% of the variance in AI integration, $R^2 = .40$, adjusted $R^2 = .39$.

Teacher AI readiness emerged as the strongest predictor of classroom integration ($\beta = .41$, $p < .001$). Teachers with greater readiness reported substantially greater use of AI even after other teacher and institutional characteristics were taken into account.

Institutional support was also independently associated with AI integration ($\beta = .23$, $p < .001$). Previous participation in formal AI-related professional development remained a significant positive predictor of classroom integration ($\beta = .16$, $p < .001$), while perceived barriers were negatively associated with integration ($\beta = -.14$, $p = .002$).

Teaching experience demonstrated a comparatively small negative relationship with AI integration ($\beta = -.07$, $p = .041$). Instructional level also retained a modest association with AI integration, with high school teachers reporting greater use than elementary teachers after adjustment for the remaining predictors ($\beta = .09$, $p = .018$).

Table 3 Multiple Regression Predicting Classroom AI Integration

Predictor	β	p
AI readiness	.41	< .001
Institutional support	.23	< .001
Previous AI professional development	.16	< .001
Perceived barriers	-.14	.002

Teaching experience	-.07	.041
High school level	.09	.018
Middle school level	.05	.146

Note. Elementary school served as the reference category for instructional level. Model $R^2 = .40$; adjusted $R^2 = .39$.

Additional analyses examining the four dimensions of readiness showed that perceived AI ability had the strongest independent association with classroom integration ($\beta = .31$, $p < .001$), followed by cognition ($\beta = .19$, $p < .001$). Vision demonstrated a smaller positive relationship with integration ($\beta = .11$, $p = .012$). Ethical readiness was not independently associated with frequency of AI integration after the other readiness dimensions were included in the model ($\beta = .05$, $p = .184$).

The absence of a significant independent association between ethics and frequency of AI use did not indicate that ethical readiness was unimportant. Rather, the result indicated that ethical awareness did not independently predict how frequently teachers used AI after their knowledge and practical ability were considered.

Open Ended Responses

Of the 526 participants, 437 provided at least one substantive response to the open-ended questions. Qualitative content analysis identified several recurring themes concerning teachers' experiences with AI. Because individual responses could receive more than one code, theme frequencies were not mutually exclusive.

The most common theme involved insufficient training and the desire for practical professional development. This theme appeared in 241 responses (55.1%). Teachers frequently emphasized the need for training that demonstrated how AI could be applied to authentic instructional activities rather than simply introducing particular AI applications.

Uncertainty regarding school and district policies was identified in 186 responses (42.6%). Teachers described difficulty determining which AI applications were permitted, what forms of student use were acceptable, and how existing academic integrity expectations applied to generative AI.

Concerns regarding the accuracy and reliability of AI-generated information appeared in 173 responses (39.6%). Teachers described the need to verify outputs and expressed concern about students accepting generated information without adequate evaluation.

Student dependence, inappropriate use, or possible reductions in independent thinking appeared in 161 responses (36.8%). Participants frequently distinguished between using AI as a learning support and allowing AI to substitute for students' own intellectual effort.

Privacy, ethics, and responsible data use appeared in 128 responses (29.3%), while insufficient time to learn

and experiment with AI appeared in 119 responses (27.2%).

Across the responses, teachers generally did not describe professional development as a need for basic technological instruction alone. Instead, teachers emphasized practical pedagogical application, evaluation of AI outputs, student use, privacy, academic integrity, and clearer institutional expectations.

Summary of Findings

The results showed substantial variation in AI readiness and classroom integration among K-12 teachers. Teachers demonstrated comparatively high ethical awareness and positive perceptions of AI's future importance but lower confidence in their practical ability to integrate AI into instruction. Professional development needs remained substantial, particularly in relation to evaluating AI-generated information, student privacy, bias, academic integrity, and classroom governance.

AI readiness was strongly associated with classroom AI integration, and teachers who had received formal professional development demonstrated both greater readiness and substantially higher levels of classroom AI use. Institutional support also emerged as an independent predictor of integration, while perceived barriers were negatively related to use.

Taken together, the findings suggest that classroom AI adoption reflected not only individual teacher readiness but also the professional learning and institutional conditions within which teachers worked.

Discussion

The findings provide an integrated account of how teacher readiness, professional learning, institutional support, and perceived barriers are associated with AI use in K-12 educational practice. Teachers reported a moderate overall level of AI readiness, but readiness was not uniform across dimensions. Ethical readiness received the highest ratings, followed by vision and cognition, whereas practical ability received the lowest mean. This pattern is consistent with multidimensional conceptions of AI readiness in which knowing that AI raises important educational and ethical questions does not necessarily mean that teachers feel capable of applying AI effectively in day-to-day instruction (Celik, 2023; Wang et al., 2023).

The distinction between ethical readiness and practical ability is especially important. Ability had the strongest independent association with classroom AI integration when the four readiness dimensions were examined together, while ethical readiness was not independently associated with frequency of use after cognition, ability, and vision were considered. This result should not be interpreted as evidence that ethics is unimportant. The dependent variable measured how frequently and broadly teachers used AI, whereas ethical readiness concerns whether AI use is responsible, fair, privacy-protective, and appropriately bounded. A teacher may possess strong ethical awareness and intentionally use AI sparingly, while another teacher may use AI frequently because of greater operational competence. Future research should therefore

distinguish frequency of AI use from the pedagogical quality and ethical appropriateness of that use.

Professional development was one of the clearest differentiators in the study. Teachers who had received formal AI-related professional development reported higher readiness, lower unmet professional development needs, and substantially greater classroom AI integration than teachers who had not received formal training. The integration difference was particularly large. These findings align with prior research showing that professional learning can strengthen teachers' understanding of AI and increase willingness to use AI-supported educational technologies when training combines conceptual explanation with concrete pedagogical application and preserves teacher agency (Nazaretsky et al., 2022). At the same time, the present study is cross-sectional, so the observed differences cannot establish that professional development caused the higher readiness or integration. Teachers who were already interested in AI may also have been more likely to seek training.

The content of teachers' reported professional development needs is also informative. The highest-rated needs concerned evaluating the accuracy of AI-generated information, protecting student privacy and data, identifying bias and fairness concerns, evaluating AI-generated student work, and establishing appropriate expectations for student AI use. By contrast, basic awareness of generative AI tools and basic prompting strategies were rated somewhat lower. This pattern suggests that professional learning needs are moving beyond simple tool exposure toward evaluative judgment, classroom governance, assessment, and responsible use. Such priorities are consistent with calls for teacher AI competence to include technological knowledge, pedagogy, human judgment, and ethical responsibility rather than operational skill alone (Celik, 2023; Miao & Cukurova, 2024).

Institutional conditions were also consequential. Institutional support was positively associated with both readiness and classroom integration and remained an independent predictor of integration in the multivariable model. Teachers also identified insufficient professional development, lack of time, unclear policies, accuracy concerns, and academic integrity as prominent barriers. These findings reinforce the view that AI adoption is not solely an individual teacher decision. Schools and districts shape the conditions under which teachers can experiment responsibly by providing approved tools, professional learning, technical assistance, policy clarity, collaboration opportunities, and time to develop competence (Diliberti et al., 2024; Sanders et al., 2024).

The study further demonstrates why teacher-facing and student-facing AI use should not be treated as interchangeable. Teacher-facing applications were significantly more common than student-facing applications. Teachers can use AI for lesson planning, instructional material development, differentiation, assessment preparation, or feedback without requiring students to interact directly with an AI system.

Student-facing integration introduces additional questions involving developmental appropriateness, academic integrity, privacy, supervision, and the preservation of independent student thinking. Separating these forms of use provides a more precise account of how AI is entering schools and may help districts develop differentiated policies for teacher use and student use.

Differences by instructional level also merit attention. Elementary teachers reported lower overall AI integration than middle and high school teachers, while the difference between middle and high school teachers was not statistically significant. This pattern is broadly consistent with earlier national evidence that AI adoption has varied by grade level and teaching context (Diliberti et al., 2024). The finding may reflect differences in curricular demands, student age, assessment practices, or the perceived suitability of currently available generative AI tools. Because the present study did not test those mechanisms directly, they should be examined in future research rather than inferred from grade-level differences alone.

The open-ended responses deepen the quantitative findings. Teachers most frequently emphasized insufficient training and the need for practical professional development, followed by uncertainty about school and district policies, concerns about the accuracy of AI-generated information, student dependence or inappropriate use, privacy and ethics, and insufficient time to learn. The convergence between the quantitative barrier ratings and the open-ended themes strengthens the interpretation that effective AI integration is simultaneously a competence, governance, and organizational-support challenge.

Practical Implications

For schools and districts, the results suggest that professional development should be organized around competencies and authentic teaching problems rather than around demonstrations of individual platforms. Training should include opportunities to evaluate AI-generated information, identify bias, protect student data, redesign assignments, develop appropriate expectations for student use, and determine when AI supports or undermines learning. Because teachers who reported greater institutional support also reported greater integration, professional learning is likely to be most useful when accompanied by clear policies, leadership guidance, access to approved tools, technical support, collegial learning, and protected time for experimentation.

Teacher preparation programs can likewise incorporate AI readiness across technological, pedagogical, and ethical domains. Preservice and in-service educators need opportunities to develop AI-specific knowledge while also applying that knowledge to curriculum, assessment, differentiation, accessibility, academic integrity, and professional decision-making. Preparing teachers only to operate AI applications would leave important dimensions of professional judgment underdeveloped.

Limitations

Several limitations should be considered when interpreting the findings. First, the cross-sectional design identifies associations at one point in time and does not establish causal relationships. For example, teachers who received professional development reported greater AI integration, but the design cannot determine whether training increased use, whether teachers already inclined to use AI were more likely to obtain training, or whether both processes occurred.

Second, the study relied primarily on self-report measures. Teachers' reports of readiness, institutional support, barriers, and AI use may be affected by recall error, social desirability, or differences in how respondents interpret frequency and competence. The use of multiple constructs within the same questionnaire also creates the possibility of common method variance. Future studies can strengthen inference by combining survey responses with behavioral logs, instructional artifacts, classroom observations, or other external indicators of AI use.

Third, participants were recruited through a research panel and the sample should not be treated as a probability-based estimate of all U.S. K-12 teachers. The 90.1% figure reported in the study represents the proportion of survey initiators retained after eligibility and data-quality screening, not a conventional response rate based on all invitations sent. Selection into the panel and into the study may therefore limit representativeness, even though participants represented multiple regions, school types, instructional levels, and subject areas.

Fourth, several measures were adapted or developed for the study. Although the readiness measure demonstrated strong reliability and the four-factor confirmatory model showed acceptable fit, continued validation is warranted for the AI integration, professional development needs, institutional support, and barriers measures across different teacher populations and school contexts. Future research should examine convergent and discriminant validity and, where feasible, measurement invariance across grade levels and other educator groups.

Fifth, the qualitative component was based on brief open-ended survey responses rather than in-depth interviews. The frequencies therefore indicate the prevalence of themes within the written responses but do not provide the depth obtainable through a dedicated qualitative design. Future mixed-methods work could use interviews or focus groups to explore how teachers interpret institutional policies, negotiate student AI use, and translate professional development into classroom practice.

Future Research

Future research should extend the present findings longitudinally and experimentally. Longitudinal studies can examine whether AI readiness and institutional support predict changes in classroom use over time.

Professional development interventions can test whether sustained, practice-based AI training produces improvements in readiness, instructional quality, and responsible-use behaviors. Future work should also examine student outcomes and distinguish between the frequency, quality, and appropriateness of AI integration. Nationally representative sampling would be especially useful for determining how readiness and access vary across regions, school systems, subjects, and student populations.

Conclusion

Artificial intelligence is becoming part of teachers' professional environment, but access to AI tools alone is insufficient for meaningful educational integration. In this study of 526 practicing K-12 teachers in the United States, teachers reported stronger ethical awareness and expectations about AI's future role than confidence in their practical ability to use AI. Readiness was strongly associated with classroom integration, while formal professional development and institutional support were also positively associated with use and perceived barriers were negatively associated with integration. Teachers' strongest professional learning needs centered on accuracy, privacy, bias, assessment, academic integrity, and classroom expectations for student use. Taken together, the findings indicate that responsible AI integration depends on a combination of teacher competence, sustained professional learning, and supportive organizational conditions. Schools, districts, and teacher preparation programs should therefore approach AI implementation as a professional-capacity and governance challenge, not simply as a technology-access initiative.

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