The Role of Artificial Intelligence in the Teaching Profession: A Systematic Review of Competencies, Challenges, and Development Directions

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Abstract

Background - The integration of artificial intelligence (AI) in education presents both opportunities and challenges. Teachers are expected to go beyond mere technology adoption and develop ethical, reflective, and collaborative competencies to ensure meaningful AI use in classrooms.

Purpose - This study aims to (1) identify essential teacher competencies for AI integration, (2) analyze key challenges in implementing AI in educational contexts, and (3) propose directions for sustainable and future-oriented professional development.

Method/approach - A systematic literature review (SLR) was conducted on 12 peer-reviewed articles indexed in Scopus, selected using the keywords *"Artificial Intelligence"*, *"teacher competence"*, *"AI in education"*, and *"TPACK"* for English-language articles published between 2020–2025. Thematic analysis was applied, with themes validated through iterative coding and cross-checking to ensure reliability.

Findings - The review reveals three major teacher competency domains: (1) AI literacy and ethical awareness, (2) data management and digital pedagogical design, and (3) collaborative and reflective practice. Challenges include limited infrastructure, ethical concerns, resistance to pedagogical change, and insufficient AI-focused training.

Conclusions - This study recommends using the AI-TPACK framework, design thinking principles, and growth mindset approaches to guide teacher professional development. The findings provide theoretical contributions by synthesizing emerging teacher competency models and practical implications for policymakers and teacher training institutions.

Novelty/Originality/Value - Thus, PBL is proven to have an effect on students' mathematical creative thinking skills.

Keywords: Artificial Intelligence; Teachers; TPACK

INTRODUCTION

The development of information technology 4.0 and 5.0 has transformed human work, making it easier (Subandowo, 2022). AI is increasingly applied across sectors to automate tasks and support human decision-making. AI is being adopted across diverse sectors, including education (Zahara et al., 2023). Artificial intelligence or AI in education is designed to simplify all processes within the educational sphere, such as the learning process, student data management, educational evaluation, and others. AI supports both student learning and teacher innovation. AI will provide new experiences for students and change their learning styles (Zahara et al., 2023).

In the learning process, methods and strategies that are suboptimal, incomplete, and unsuitable for students' needs are often found (Syapparuddin et al., 2020). Students often fail to understand the material well due to methods that are inappropriate and uninteresting to them. Therefore, innovation in the learning process is needed to increase students' interest. This is expected to change the process of achieving educational goals. In this context, AI offers opportunities for designing more personalised and engaging learning experiences. Schools can utilize AI to innovate in learning (Nur et al., 2022). In Indonesia, the use of AI is still relatively low. Therefore, AI needs to be integrated into education in Indonesia. The presence of AI will bring about changes in the quality of student learning and character development. Good education can improve student character (Mulianingsih et al., 2020).

In this context, teachers are required to understand technology and possess specialized competencies in effectively and ethically utilizing AI (Alghafiqi & Munajat, 2022; Hamal et al., 2022). The role of teachers has shifted from being information providers to learning facilitators who can manage digital learning environments, utilize data, and integrate innovative technology into meaningful pedagogical practices. AI literacy, data management skills, and cross-disciplinary collaboration are now integral to 21st-century teacher professional competencies (Soliman et al., 2024; W. Wu et al., 2023). However, the transition to AI-based education also faces several complex challenges. On the one hand, many teachers have not received adequate training in understanding and implementing AI technology.

On the other hand, there are concerns about the impact of AI on data security, fairness in the learning process, and the potential marginalization of humanistic aspects in education. Infrastructure gaps and resistance to change also exacerbate these challenges, particularly in less developed educational environments. While several studies discuss AI in education, most focus on general technology adoption rather than synthesizing teacher competencies specific to AI integration. Few reviews link these competencies with concrete professional development strategies, creating a gap in understanding how to prepare teachers for sustainable AI integration.

It is important to formulate a direction for developing relevant and contextual teacher competencies amid these challenges. Continuous education and training ensure teachers are prepared for change (Miguel-Revilla et al., 2020; Sun et al., 2023). The integration of AI is reshaping the teaching profession by introducing new competencies, challenges, and directions for professional growth (Feldman-Maggor et al., 2024), reinforcing the need for a systematic investigation. Therefore, this study systematically reviews recent literature (2020–2025) to identify essential teacher competencies, analyses implementation challenges, and proposes future-oriented professional development directions (Dogan et al., 2025a; Karataş & Ataç, 2025a).

Integrating Artificial Intelligence (AI) into education is transforming the teaching profession by introducing new competencies, challenges, and directions for development (Feldman-Maggor et al., 2024). AI technologies, such as generative AI and machine learning, enhance personalized learning, automate assessment, and provide data-driven insights, requiring teachers to adapt and develop new skills. This transformation is about adopting new tools and redefining the role of teachers as facilitators of learning in an AI-supported environment. This study is novel as it systematically synthesizes teacher competencies for AI integration, identifies key implementation challenges, and proposes evidence-based professional development directions linking AI-TPACK, design thinking, and growth mindset principles. The following sections explore the competencies required, the challenges faced, and the future development directions for teachers in the AI era.

Quality education is a fundamental pillar in building superior, competitive human resources

that contribute to the progress and welfare of a nation. A well-designed, research-based education system that is in line with the needs of the times is the main key in realizing optimal education quality (Rahman et al., 2022). Education design should include a relevant curriculum, adaptive learning materials, and innovative and effective teaching methods (Kemendikbud, 2022). In addition, education must continue to be oriented towards change and continuous improvement to ensure quality improvement in accordance with global challenges and the needs of society.

METHODS

This study uses a systematic literature review (SLR) approach to explore in depth the competencies required of teachers in facing the development of artificial intelligence (AI), the challenges faced, and the direction of teacher professional development based on AI integration. The review followed the PRISMA protocol to ensure transparency and replicability. The analysis was conducted through the four stages of identification, screening, eligibility, and inclusion. In the identification stage, an initial search of the Scopus database was conducted using the keywords 'Artificial Intelligence' OR 'AI in education' AND 'teacher professional development' OR 'teacher competence' OR 'TPACK.' This search yielded 269 documents. Scopus was selected because of its comprehensive indexing of peer-reviewed educational research. To minimise database bias, reference lists of selected articles were also screened manually to identify additional relevant studies.

The screening stage involved applying inclusion criteria: (1) empirical or conceptual studies on teacher competencies, challenges, or professional development related to AI integration; (2) peer-reviewed journal publications between 2020 and 2025; and (3) articles written in English. Exclusion criteria included conference abstracts, editorials, studies focusing solely on students or institutional policies without reference to teacher competencies, and duplicate records. After screening for language, year, and relevance, 102 articles remained.

Two reviewers independently assessed titles and abstracts for relevance using Rayyan. Discrepancies were resolved through discussion until consensus was reached. From the eligibility screening, 12 relevant articles that met all criteria were obtained for full-text review and thematic analysis. Thematic coding was conducted iteratively and cross-checked to ensure reliability of interpretation. The analysis focused on three questions: (1) What competencies do teachers need to possess in the AI era? (2) What challenges do teachers face in adopting AI? (3) What are the potential directions for development and training within the TPACK framework?

Figure 1 shows the complete data analysis process, including record identification, screening, eligibility assessment, inclusion of final studies, and the thematic coding and synthesis stages. Potential publication bias was mitigated by including both conceptual and empirical studies and considering studies reporting diverse outcomes.

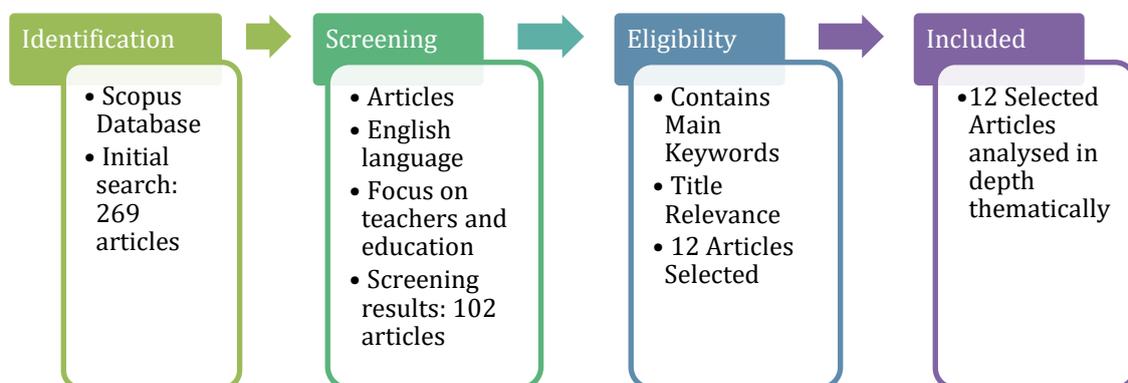The data analysis process can be seen in Figure 1 below:

Identification	Screening	Eligibility	Included
• Scopus Database • Initial search: 269 articles	• Articles • English language • Focus on teachers and education • Screening results: 102 articles	• Contains Main Keywords • Title Relevance • 12 Articles Selected	• 12 Selected Articles analysed in depth thematically

Figure 1. Data Analysis Process

RESULTS AND DISCUSSION

Based on the data analysis process, 12 articles were analyzed thematically regarding teacher competencies in the future, challenges for teachers in the AI era, and the direction of teacher professional development in the future. The results of the study can be seen in Table 1 below:

Table 1. Summary of Included Studies

Authors	Title	Results
Karataş & Ataç (2025)	When TPACK meets artificial intelligence: Analyzing TPACK and AI-TPACK components through structural equation modelling	This study found that prospective English teachers have high competencies in certain aspects of TPACK and AI-TPACK, such as technology knowledge (TK) and AI (AI-TK), but are still weak in full integration (TPACK) and AI ethics. Gender and AI experience influence their abilities. There is a positive correlation between TPACK and AI-TPACK, indicating the need for integrated teacher training focused on AI ethics.
Yang et al. (2025)	The impact of TPACK on teachers' willingness to integrate generative artificial intelligence (GenAI): The moderating role of negative emotions and the buffering effects of need satisfaction	This study found that TPACK enhances teachers' willingness to integrate generative AI, but its effects may weaken due to negative emotions. Satisfaction of competency needs and social relationships are more effective in mitigating these negative effects than autonomy. These findings emphasize the importance of emotional and psychological support in promoting AI adoption by teachers.
Runge et al. (2025)	Acceptance of Pre-Service Teachers Towards Artificial Intelligence (AI): The Role of AI-Related Teacher Training Courses and AI-TPACK Within the Technology Acceptance Model	This study shows that prospective teachers' participation in AI-related courses increases AI-TPACK and perceptions of AI benefits. AI-TPACK also positively influences perceptions of AI ease and usefulness, which in turn increases intentions and actual use of AI in professional tasks. These findings expand the TAM model by emphasizing the importance of AI training and AI-TPACK in promoting AI acceptance among prospective teachers.
Aguilar-Cruz & Salas-Pilco (2025)	Teachers' perceptions of artificial intelligence in Colombia: AI technological access, AI teacher professional development and AI ethical awareness	This study found that teachers in public schools in Caquetá, Colombia, view AI as useful as a virtual assistant, but face challenges in the form of a lack of knowledge and resources. They are also concerned that AI could hinder the development of students' critical thinking skills. Therefore, continuous professional development is needed to support the integration of AI in education.
Chan & Tang (2025)	Evaluating English Teachers' Artificial Intelligence Readiness and Training Needs with a TPACK-Based Model	This study found that prospective English teachers in Hong Kong are generally ready to integrate AI into learning, especially when supported by technology pedagogical knowledge (TPK) and information literacy (IL). The study emphasizes the need for professional training related to the selection, application, and monitoring of AI, as well as AI-based pedagogical design. The developed instrument was found to be valid and can be used for larger-scale studies with a mixed-methods approach.
Dogan et al., (2025)	Artificial intelligence professional development: a systematic review of TPACK, designs, and effects for teacher learning	This study is a systematic review using the PRISMA protocol to evaluate teacher professional development (PD) programmers related to AI within the TPACK framework. The results identify the TPACK domains used, the types of AI tools taught, the training formats, effective features, and the real-world impact on teachers after participating in PD. This study provides strategic guidance

		for planning and evaluating AI initiatives in teacher education.
Kohnke & Zou (2025)	Artificial Intelligence Integration in TESOL Teacher Education: Promoting a Critical Lens Guided by TPACK and SAMR	This article emphasizes the important role of TESOL teacher educators in equipping teachers with skills to address GenAI. By leveraging the TPACK and SAMR frameworks, this article demonstrates how to integrate AI pedagogically, ethically, and fairly. Issues such as bias, equitable access, and cultural representation are key concerns, and guidance is provided on AI integration that supports social justice in language education.
Altawalbeh & Al-Said (2025)	Applying UTAUT and TPACK in predicting English lecturers' intention to use artificial intelligence	This study shows that performance expectations, ease of use, social influence, and institutional support significantly influence English language instructors' intentions to adopt AI. TPACK components, particularly TPK and TCK, serve as important mediators in this relationship. These findings underscore the importance of professional development programmers and institutional support in promoting AI adoption in English language teaching.
Al-Abdullatif (2024)	Modeling Teachers' Acceptance of Generative Artificial Intelligence Use in Higher Education: The Role of AI Literacy, Intelligent TPACK, and Perceived Trust	This study found that AI literacy and perceptions of ease of use are key factors influencing university lecturers' acceptance of GenAI. Intelligent TPACK and trust act as important mediators. This study underscores the need for practical professional training focused on enhancing AI literacy and hands-on experience with GenAI tools to support effective integration in learning.
Kim (2024)	Development of a TPACK Educational Program to Enhance Pre-service Teachers' Teaching Expertise in Artificial Intelligence Convergence Education	This study shows that TPACK-based AI education programmers significantly improve AI convergence teaching skills among prospective teachers in South Korea. Compared to traditional AI education, this programmed provides clear advantages, particularly in PCK and TPACK. These results emphasize the importance of integrated and specialized training approaches to prepare teachers for AI-based education.
Celik (2023)	Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education	This study developed a scale for measuring teachers' knowledge in the use of instructional AI by expanding the TPACK framework to include ethical aspects. The results show that technological knowledge (TK) helps teachers evaluate AI decisions, but it is not sufficient without being combined with pedagogical knowledge (PK). Effective AI integration requires TPK and ethical awareness. This study then proposes a new framework called Intelligent-TPACK to support the pedagogical and ethical integration of AI in education.
Al-Zyoud (2020)	The role of artificial intelligence in teacher professional development	This study reviews the literature to analyze the role and potential of AI in teacher professional development. The results show that various intelligent applications and areas of AI can be utilized to improve teacher qualifications. Recommendations include: the development of AI-based educational software, specialized training pathways, the provision of accurate databases, and a training environment that supports AI integration, as well as global data connectivity to support teachers' careers.

Essential Competencies for Teachers in the Age of AI

In the face of the AI era, teachers are required to possess a new set of competencies relevant to the latest technological advancements. The development of artificial intelligence (AI) technology has necessitated a redefinition of teachers' professional competencies in the 21st century. Numerous studies indicate that the Technological Pedagogical Content Knowledge

(TPACK) framework serves as the primary foundation for understanding teachers' readiness to adopt AI in educational practice. However, contemporary literature has also expanded the TPACK concept into AI-TPACK or Intelligent-TPACK, a framework that combines ethical competencies, smart technology literacy, and data-driven pedagogical skills (Aguilar-Cruz & Salas-Pilco, 2025; Dogan et al., 2025; Runge et al., 2025)

First, AI literacy serves as the foundational pillar. Teachers require systematic foundational training in the use and understanding of AI applications to effectively integrate this technology into their teaching practices (Ismail et al., 2024). This literacy encompasses not only technical proficiency in using the tools but also critical understanding of how algorithms function, the potential biases within systems, and the ethical considerations of their use in an educational context. Research by Ismail et al. (2024) and Panitsides & Poulimenou (2024) highlights the importance of AI literacy as a new skill that teachers must possess. This literacy includes an understanding of how algorithms work, potential biases in AI systems, and the ability to evaluate the accuracy and social impact of the systems used. Additionally, data management skills have emerged as a critical competency, as AI-based adaptive and personalized learning systems require teachers who can critically interpret data and respond appropriately to students' learning needs.

Secondly, teachers must master data management skills. In the era of data-driven learning, the ability to collect, interpret, and analyze data has become crucial. With these skills, teachers can optimally collaborate with AI systems, such as adaptive learning platforms or student monitoring dashboards, design appropriate interventions and personalize students' learning experiences (Panitsides & Poulimenou, 2024). This creates opportunities for teachers to make more accurate and responsive data-driven decisions based on the individual needs of learners. In the context of pre-service teachers, research findings from South Korea by Kim (2024) indicate that AI-TPACK-based training is more effective than traditional AI training, particularly in developing convergent teaching competencies across pedagogy, content, and technology. The most significant improvements were observed in the Pedagogical Content Knowledge (PCK) dimension and overall TPACK. This indicates that systematically designed training that integrates pedagogical and technological approaches can equip teachers with more relevant competencies to integrate AI into their classrooms.

Furthermore, several studies also highlight the need for cross-disciplinary collaboration between teachers and AI technology developers (Karataş & Yüce, 2024; Kohnke & Zou, 2025). Teachers are expected not only to be users of technology but also strategic partners in designing AI tools that are relevant and ethical for education. Thus, teachers' competencies in the future will not only lie in the use of technology but also in reflective, ethical, and collaborative skills within the context of an ever-changing digital landscape. Teachers no longer work exclusively within the realm of pedagogy but must interact with technology developers and AI experts. This collaboration aims to ensure that the AI tools and systems developed are truly in line with educational needs and support relevant, ethical, and inclusive learning practices (Celik et al., 2022). Through active dialogue with technology stakeholders, teachers can provide critical input on feature design, content, and context of use to make them more contextual to the world of education.

Challenges of AI Integration in Education
Ethical Issues

Amidst the enormous potential of artificial intelligence in education, there are also a number of crucial challenges that need to be taken seriously. One of these is ethical issues. The use of AI in education is not without the risk of algorithmic bias, where AI systems can generate unfair decisions or recommendations based on non-representative data. Additionally, issues of

student privacy and data security are of significant concern, especially when personal data and student performance are processed by AI systems without adequate oversight (Kayyali, 2024; Xiao et al., 2025). Therefore, a strict ethical and regulatory framework is needed to ensure that the use of AI remains fair, transparent, and protects the rights of students.

Ethical issues in the use of AI are the most consistent theme in the literature. The use of AI based on machine learning algorithms risks containing algorithmic bias, which could ultimately result in unfair recommendations or decisions for students. As emphasized in the study Yang et al. (2025), teachers are concerned that AI systems may store and process student data without adequate human control, thereby opening the door to privacy violations. Furthermore, in the study Kohnke & Zou (2025) the integration of AI in language learning (TESOL) also raises sociopolitical and ethical challenges related to cultural bias, unequal access, and non-inclusive content representation. These issues highlight the importance of developing an ethical framework and critically evaluating AI tools in education, as well as the need for teachers to be competent in assessing the accuracy and fairness of the results presented by AI systems.

Infrastructure Limitations

In addition to ethical issues, infrastructure limitations are also a significant barrier to the implementation of AI technology in schools. Many schools, particularly in areas with limited budgets, lack essential infrastructure such as stable internet connections, adequate hardware, or access to affordable AI platforms (Xiao et al., 2025). Such conditions exacerbate the digital divide between urban schools and remote areas, as well as between teachers with access to technology and those without. As highlighted in studies Aguilar-Cruz & Salas-Pilco, 2025 and Al-Zyoud (2020) teachers, especially in developing countries or underdeveloped regions, face real challenges due to insufficient digital infrastructure. For example, teachers in areas like Amazonian Colombia face limitations in accessing devices, stable internet connections, and relevant training in AI utilization. This creates a digital divide between schools that can access AI technology and those that cannot.

It is not only physical limitations but also software limitations and technical support that pose barriers. In many cases, teachers lack the resources to explore or integrate AI into daily learning, let alone personalize teaching based on data. Not all schools have adequate facilities and infrastructure. This issue is not new; it is a long-standing problem in various regions, including Indonesia. In Indonesia itself, there is a significant disparity in infrastructure between urban and rural schools. This requires preventive efforts from the government to improve the equitable distribution of facilities and infrastructure, particularly in terms of network access. Some schools have adequate facilities and infrastructure but still face difficulties in accessing the internet. If internet access remains a challenge, this will hinder or slow down progress in a region's ability to access the global world, including AI.

Resistance to Change

The next challenge relates to resistance to change, both psychologically and culturally. Not all teachers welcome AI as a positive development. Many believe that AI will eliminate the role of teachers. Some may feel threatened, believing that this technology will replace their role as educators. Additionally, the lack of digital literacy among teachers further exacerbates their concerns (Ismail et al., 2024). This fear of change can be a major obstacle in the process of adopting AI in schools. Therefore, a humanistic and transformative approach is needed through training, mentoring, and strengthening the understanding that AI is a tool, not a replacement.

In addition to external challenges, internal challenges of a psychological and cultural nature are also a concern. Teachers' fear of losing their professional role and status amid the emergence of technology capable of automating various administrative and pedagogical tasks. This fear often

leads to resistance to change, both explicitly and implicitly (Al-Abdullatif, 2024; Moorhouse et al., 2024; Yang et al., 2025). Research Kohnke & Zou (2025) indicates that teachers' roles in maintaining pedagogical integrity, social justice, and professional ethics are increasingly marginalized if AI is used unwisely. As a result, some teachers choose to 'keep their distance' from technology or use it only to a limited extent. This is exacerbated by a lack of comprehensive understanding of the benefits of AI, resulting in slow technological adoption.

Low AI Literacy and Limited Emotional Support

Many teachers, including pre-service teachers and English teachers, still have low AI literacy, both technically and ethically. This situation highlights the need for in-depth and reflective training to build their professional readiness in the AI era (Chan & Tang, 2025; Karataş & Ataç, 2025). In a study Yang et al., 2025) it was found that emotional and psychological support plays a crucial role in teachers' readiness to adopt AI. Factors such as negative emotions, lack of self-confidence, and technological stress significantly reduce teachers' intentions to use AI, even though they possess basic TPACK competencies. Interestingly, psychological needs for competence and social connectedness (relatedness) proved more effective in reducing negative effects than simply providing autonomy. This highlights the importance of creating supportive learning communities for teachers in the AI adoption process.

Policy, Curriculum, and Institutional Support Disparities

Policy disparities in educational institutions also pose challenges in the implementation of AI in schools, due to the lack of clear policies and strong institutional support. Research Al-Zyoud (2020) emphasis the importance of developing AI-based training pathways supported by a national training system, as well as educational software designed specifically to support teacher professional development. Without policies that priority teachers, the implementation of AI in schools will remain nothing more than a slogan without direction. Teachers need regulatory and structural support in the form of time for training, incentives for innovation, and the presence of a technology support team at the educational unit level. Policies must also include the protection of teachers' and students' rights, so that AI integration does not compromise basic educational principles. Additionally, there needs to be privacy security for teachers and students, protection of personal data, and a supportive digital culture.

Direction of Development Towards Reflective and Adaptive Teachers
Designing TPACK-AI-Based Programmers

Based on previous research, there is a need for teacher professional development programmers based on the Technological Pedagogical Content Knowledge (TPACK) framework, integrating TPACK AI. The TPACK model emphasizes the importance of integrating three types of knowledge: knowledge about technology, pedagogy, and content. A digitally competent teacher not only master's technology but also knows how to use it effectively to teach specific content (Czok et al., 2023; Luo et al., 2023; Merjovaara et al., 2024). This framework emphasizes that mastery of technology alone is insufficient; teachers must be able to integrate technology into meaningful content and pedagogical strategies.

These studies indicate that AI-based TPACK training can be utilized by policymakers to enhance teachers' competencies in designing data-driven and personalized learning, encourage teachers to become active users in AI-based learning, and help teachers understand how AI works, its limitations, and its potential for enhancing learning effectiveness (Karataş & Ataç, 2025; Kim, 2024). Training using the AI-TPACK approach has also been proven to enhance effectiveness in the Pedagogical Content Knowledge and Technological Pedagogical Knowledge components,

particularly among preservice teachers who lack field experience (Kim, 2024). This indicates that training should begin early in the formation of teachers' professional identities (Karataş & Ataç, 2025).

Design Thinking and Growth Mindset as a Transformational Training Framework

The integration of AI into educational practices is very helpful for teachers. With design thinking, teachers can solve problems in learning. Design thinking will help teachers to identify the needs of students. Some key elements of Design Thinking for teachers include empathy, which helps teachers understand students more deeply and identify their needs. This is crucial in designing AI for learning. Teachers can personalize AI in learning and design more adaptive learning experiences (Caires et al., 2024; Rahimi, 2025). Second, problem formulation. Design thinking is useful for teachers to solve the right problems and find the most relevant solutions. For example, integrating ChatGPT to find the most innovative solutions (Saritepeci & Yildiz Durak, 2024; Y. Wu et al., 2024). Third, creating prototypes. Design thinking can assist teachers in creating prototypes by integrating AI to refine the developed tools and testing how effective the prototypes are (Rahimi, 2025; Saritepeci & Yildiz Durak, 2024). In summary, design thinking helps teachers create a robust framework for integrating AI into teaching practices. By focusing on empathy, problem definition, ideation, prototyping, and testing, teachers can create innovative and personalized learning experiences that enhance student engagement and learning outcomes. However, addressing ethical and practical challenges and providing adequate teacher training are crucial for the successful implementation of AI in education.

Several studies implicitly suggest the importance of incorporating Design Thinking approaches and fostering a growth mindset in teacher development programmers (Chan & Tang, 2025; Kohnke & Zou, 2025; Yang et al., 2025). Teachers are not merely faced with technological advancements but also act as learning designers, problem solvers, and fulfil the needs of students. Therefore, a teacher needs to have Design Thinking to think professionally. Design thinking is not merely about utilizing technology but also encompasses empathy for students, the courage to experiment, and self-improvement in AI-based teaching. Teachers who participate in AI-TPACK-based training or development show significant improvements in their reflective abilities regarding technology integration (Karataş & Ataç, 2025b; Runge et al., 2025). However, this improvement is not without reason, as it is rooted in teaching literacy within the Design Thinking framework. Even in Dogan et al. (2025b) research, it is stated that without a combination of ethical understanding of technology and pedagogy, teachers remain mere operators rather than innovators. A professional teacher living in the digital age must possess innovations to meet the needs of learners.

However, challenges arise when teachers become trapped by fears of mistakes, change, or failure, which should naturally be part of the technology-based learning design process. This is where a growth mindset plays a key psychological role. Teachers with a growth mindset do not view limitations in AI literacy as an end but as an opportunity for learning. They interpret mistakes as part of the design iteration process, not as indicators of failure. In Hidayati et al. (2025) research, it was proven that affective and psychological aspects such as self-confidence, social connectedness, and perceptions of competence greatly influence teachers" readiness to accept AI. Teachers who feel psychologically safe and supported to grow are more likely to accept AI as a tool to enhance their practice, not a threat to their role.

The use of AI must be framed within principles of social justice and ethical awareness, which can only be achieved if teachers are not only technically capable but also willing to reflectively evaluate and redesign their practices (Dogan et al., 2025b; Kohnke & Zou, 2025). This is the essence of mature design thinking, reinforced by a growth mindset. A growth mindset encourages

teachers to think that AI is not meant to replace the role of teachers, but rather a tool to strengthen teachers' professional competencies, making them more adaptive and empowering them in teaching. Teachers with a growth mindset will believe that AI skills can be developed through seminars, workshops, or training. The key to a growth mindset is belief in one's capacity to develop. Teachers must be confident that they are capable of learning new things, even highly technical ones, as long as they have access, time, and support.

Teachers with a growth mindset tend to welcome AI. In fact, this is an opportunity for teachers to develop various teaching methods to improve student competence. A growth mindset will make teachers view AI as an opportunity rather than a threat. Research Sulistiyani et al. (2024) indicates that with AI, teachers can create a positive learning environment. In fact, student learning outcomes improved from 35% to 90% with the implementation of AI-based media. However, challenges cannot be avoided, such as infrastructure limitations, dependency, and teacher competencies. Nevertheless, with appropriate policy regulations and collaboration among various parties, the positive impact of AI can be maximized. Furthermore, AI can even facilitate teachers' professional growth through personalized training, enabling them to adapt by integrating AI into their teaching practices (LU, 2024).

Continuous Professional Development

To ensure that teachers can adapt optimally to AI-based educational transformation, a long-term development strategy is needed that includes competency development, pedagogical innovation, and the affirmation of the human role of teachers. One of the key elements is continuous professional development. Teachers need to be involved in systematic training and capacity-building programmers that are not only technical but also reflective and contextual. Such programmers aim to equip teachers with new skills relevant to AI-supported learning ecosystems, such as adaptive learning design, learning data analysis, and AI ethics literacy (Raza, 2024). This professional development should be designed as a continuous process, not just a one-off training session. Most literature recommends teacher development through a continuous professional development (CPD) approach that is not one-off but ongoing, reflective, and practice-based (Al-Abdullatif, 2024; Chan & Tang, 2025; Dogan et al., 2025). The dynamics of teacher competencies in the era of artificial intelligence (AI), as well as the challenges and strategies for strengthening teacher professionalism in facing changes in the educational ecosystem, can be seen in Figure 2 below. This visual is designed to highlight the relationship between AI literacy mastery, the application of the AI-TPACK model, and the need for interdisciplinary collaboration in shaping future teachers who are adaptive, ethical, and competitive.
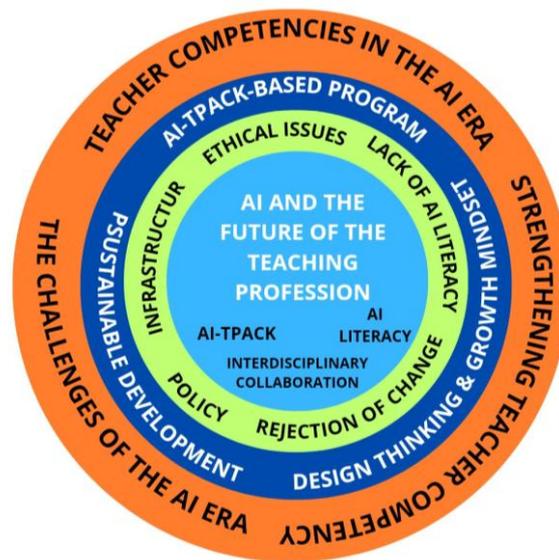
Figure 2. Visualisation of AI and the Future Teaching Profession

CONCLUSION

This study systematically reviewed 12 peer-reviewed articles on AI integration in education and synthesised key teacher competency domains: AI literacy, AI-TPACK skills, data management capabilities, and ethical awareness. These findings extend the TPACK model into an AI-TPACK+ framework that explicitly incorporates ethical and socio-technical dimensions, offering a theoretical basis for AI-specific teacher professional standards. Practically, this review highlights the urgent need for continuous and contextual professional development (CPD) programmes that integrate design thinking and growth-mindset approaches, moving beyond technical training to foster reflective and adaptive teachers. Policymakers should establish clear AI-competency standards, strengthen regulatory frameworks for ethical AI use, and ensure equitable infrastructure support. Teacher education institutions should embed AI literacy, data ethics, and collaborative problem-solving into pre-service and in-service curricula. Future research should conduct longitudinal and mixed-methods studies to evaluate the long-term effects of AI-TPACK-based training on teacher practice and student outcomes, and cross-cultural comparative studies to validate the applicability of the proposed framework in diverse educational contexts

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