AI Competency Frameworks for University Teachers: A Systematic Literature Review Based on UNESCO Dimensions

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Abstract

This article presents a systematic literature review on artificial intelligence (AI) competency frameworks for university teachers, based on UNESCO dimensions. The study follows the PRISMA 2020 methodology and analyses 12 peer-reviewed articles published between 2017 and June 2025.

Five key competency dimensions are identified: human-centred mindset, AI ethics, AI foundations and applications, AI pedagogy, and professional development. Findings reveal a predominance of technical approaches over pedagogical and ethical perspectives.

The AI foundations dimension emerges as the most developed area in the literature. In contrast, human-centred and professional development dimensions receive comparatively limited attention.

The study highlights the need for teachers to understand both technical aspects and the societal implications of AI. It also emphasizes the importance of integrating ethical principles such as fairness, transparency, and accountability.

AI pedagogy focuses on the use of generative tools and personalized learning approaches. Continuous professional development is identified as essential for adapting teachers to technological change. The analysis also reveals a fragmented research landscape with limited collaboration among authors and institutions.

There is a strong dominance of computer science publications and limited contributions from education research.

Key challenges include technological, pedagogical, and regulatory barriers to AI adoption. The article calls for more interdisciplinary and collaborative approaches in teacher training.

In conclusion, developing AI competencies for university teachers is a critical technological, pedagogical, and ethical imperative in higher education.

Keywords

AI teacher competencies, UNESCO framework, higher education, AI pedagogy, ethical AI, AI professional development, human-centred mindset.

1. Introduction

Artificial Intelligence (AI) is transforming industries and societies from underpinning a new wave of technological advancement. It presents more complex challenges and greater opportunities for individuals, organizations and societies to manage than prior technology waves. Education and lifelong learning are key to empowering individuals to understand and shape AI's development and application in their contexts, for example through equitable access to quality learning and teaching opportunities (Carvalho et al., 2022), (Mhlanga, 2023), (Poquet, & De Laat, 2021), (Zhou et al., 2020). AI education encompasses the development and understanding of AI and its impacts, while promoting critical engagement with human institutions and choices shaping the AI ecosystem. Many globally and nationally advocacy groups, initiatives and collaborations are aiming to prepare youth for an AI-rich future. Teaching AI is a rapidly developing field of research with no defined territory and numerous approaches.

Recent discussions at academic conferences have highlighted the need for university educators to enhance AI literacy and develop effective instructional strategies for integrating AI education throughout the curriculum. Various national governments and educational bodies have published extensive reports examining the impact of AI on higher education. Additionally, technology firms and industry organizations invested in AI have created frameworks that delineate the knowledge and skills that university students require to thrive in an AI-embedded workforce. AI education is currently evolving, presenting both significant opportunities and challenges for higher education institutions. These frameworks offer diverse taxonomies and perspectives for addressing AI education at the university level. A variety of design methodologies, instructional guidelines, tools, and curriculum resources have been crafted to empower university teachers in effectively delivering AI content within their courses.

Numerous agency, responsibility, and ethical issues have been examined concerning the role of university teachers in AI education, the responsibilities of educational institutions, strategies for incorporating AI into university curricula, and methods to evaluate understanding and engagement with AI beyond traditional education settings. Various plans and approaches to support AI instruction across academic programs, departments, and interdisciplinary collaborations are currently at different stages of development and implementation. Initiatives aimed at harnessing the expertise and agency of university educators to collaboratively design AI education frameworks are emerging from a synthesis of advocacy, uncertainty, and competence, collectively prompting the next phase in this area of research.

2. Literature Review

2.1. Human-Centred Mindset

The usage of AI systems in the era of Human-Centred AI (HAI) requires individuals to not only understand how AI technologies work at a fundamental level, but also to have culturally adaptive thinking about AI to enable optimally beneficial and responsible use of AI that is about them, for them. Cultural adaptability applies one's creativity to adjust the functioning of AI to social, cultural, individual, and practical workplace factors and to incorporate these non-technical aspects in its design and use for responsible AI technology adopted to culture and context (Samuel et al., 2023). Consequently, the need for a Culturally Adaptive Thinking in Education for AI (CATE-AI) framework is proposed. This framework would facilitate AI instruction in a range of educational contexts, offering valuable guidance to AI material developers in adapting AI instruction to the cultural needs of students.

As the use of Artificial Intelligence (AI) technologies across multiple domains continues to grow, a knowledge framework about how AI systems work in schools is a vital foundation for individuals to be such actors in the AI driven era. AI technologies that are prolific to the average person include

social media algorithms, facial recognition systems, online customer service chatbots, self-driving cars, and tailored recommendation systems, among others. A basic understanding of what AI is and types of AI creates a foundation knowledge to engender more advanced conceptual understanding of data and AI system functions. Such knowledge is necessary to navigate the many technological interactions in daily life, to eschew possible ill effects such as unwanted data collection, and to engage in more advanced civil participation. However, as the AI technologies that shape the everyday life of the average person do not operate in isolation, further understanding of AI is required in terms of how technological systems are nested within broader sociocultural, economic and political systems.

2.1.1. Emphasizing Human Agency

As Artificial Intelligence (AI) grows more ubiquitous, educational systems worldwide recognize the critical importance of a well-informed citizenry capable of using AI responsibly. The UNESCO Guiding Principles on AI in Education equally emphasize the importance of human agency. At the same time, AI is operating autonomously, or as "intelligent agents", threatening established norms of human control over technology, especially in the areas of critical cyber-infrastructure and political communication. AI is transforming educational settings through automated grading, adaptive programming, personalized tutoring, and AI-assisted content creation. Educational use of AI, however, raises significant ethical risks of bias, discrimination, harassment, privacy violations, intellectual property infringement, and academic dishonesty. Informed and critical AI use is becoming societally necessary to make tech companies accountable, to improve data practices, and to safeguard one's own rights (Zhou et al., 2020).

There is an opportunity for education to establish a new understanding of AI. This understanding of AI should be socially constructed, built on local reality instead of imported expert authority. This new, local, socially constructed understanding of AI would be capable of attacking the purported "AI Black Box". Informed by existing scholarly literature on informed agency, consideration should also be given to how ordinary citizens can interrogate the limits of AI and make informed choices about its use and effects. As AI systems are now engineered solely to maximize the profits of tech companies, interrogation of these systems needs to be empowered by an epistemic robustness that allows a plurality of understanding across various contexts. This is a prerequisite for the "control and responsibility of human actors" that is widely claimed as a goal of AI literacy.

2.1.2. Accountability in Teaching

Teachers in higher education often confront the challenge of being accountable for student learning and managing workload amidst increasing responsibilities. This case study examines the accountability of a two-year part-time teacher education program in China, revealing how program administrators as agents of the accountability movement framed accountability in a managerial context, resulting in increased demands on teacher educators and student teachers. While teachers adjusted their practices and recalibrated beliefs about accountability, a mix of enthusiasm and discontent emerged about the pace, focus, scope, and implications of accountability. Recommendations for program improvement embodied a conformity response to the accountability movement, potentially constraining systemic change in the long run. Implications for teacher education research and practice are also discussed.

2.1.3. Social Responsibility in Education

Social responsibility is a pedagogical and academic principle that entails an organization's obligation to facilitate the progress of the environment, the society, and individuals in an environmentally friendly and ethical manner. From the social responsibility point of view, Schools must strengthen the foundations of education from academic, pedagogical, and curriculum space. Also, schools must support relations toward both social responsibility policies and improvement

in developed countries, notwithstanding the fact that it means an exit out of conventional educational content. Justification, control, and stimulation with regard to social responsibility should fall within the range of core activities of higher education. However, it should be mentioned that fulfilling social responsibility and being socially responsible can mean many things and can have several dimensions (Giangrande et al., 2019). When examining social responsibility in education, it is essential to consider and analyze pedagogical reasons, pedagogical competence, deliberative pedagogy, self-education and individual agency, civic responsibility, social responsibility, engaged research, community services, and experiential education. Additionally, social responsibility should be approached as an unavoidable process in the development of educational sciences, education, higher education, the school, and higher educational institutions. It is important to note that the scope of socially responsible schools should always extend beyond the environment and society as well as to the students' interests and wishes. On the basis of understanding the social responsibility of education, ten statements on education's social responsibility have been composed (Vare, 2018). First, education bears social responsibility. Academic and pedagogical standards and principles shall be determined on the basis of social responsibility. Second, educational policy making and the execution of educational policy shall be socially responsible. In addition, public opinions shall be informed with regard to social responsibility procedures and approaches. Third, education shall contribute to the functioning of institutions, agencies, and organizations. Forth, value systems and value guiding principles shall be examined and considered with regard to education and the school. All knowledge with regard to history and future prospects shall be made available. Fifth, education shall contribute to the restructuring and development of society. Relying on students' interests and needs, subjects and activities along a decisional matter shall be applied. Last but not least, schools shall act as model communities for students' civic engagement and social responsibility. Social responsibility has been equivocal in its understanding and ascribed meanings. Three general kinds of underpinnings have been identified: an educationally orientated viewpoint emphasizing that social responsibility is essential to education; a science body/organisational viewpoint emphasizing social responsibility with reference to systemic, academic standards and principles; and politically orientated underpinnings where socially responsible positionality, tendering, and performance are expected from universities.

2.2. Ethics of AI

Ethics is the science that studies human behavior regarding what is right and what is wrong. Ethical education refers to the formal training, deliberation, and guidance that promote students' moral awareness so that they can reflect on, discuss, and apply moral codes in their daily interaction. Some prior studies have focused on the purpose and content of ethical education. The result findings suggest three general dimensions, referring to the particulars of ethical codes, about ethical conduct, and about moral decisions and judgments. Such methods integrating qualitative and quantitative analyses could also be used to analyze other research topics.

Educational ethics is an interdisciplinary field of study focusing on the moral dimensions of education and educational institutions and examining the obligations, responsibilities, and the rights of professionals in relation to their duties. Educational ethics also investigates the ways in which education is a moral good and the relationship of education to social justice. Educational ethics is complex and fraught with tensions and dilemmas because moral issues are complicated, uncertain, and contextual. Information and Communication Technology removes time and space barriers and makes the proposed digital world possible where both physical and virtual spaces coexist, produce, create, and reproduce knowledge, and conduct both human-to-human interactions and human-machine interactions.

Teachers are educators; metaphysically, they should aim for moral education doubtlessly so that schools could become the cradle of greatness and idealism, producing moral individuals that would contribute to the society. While regarding teachers' ethics in AI courses, some guidelines for AI design and development should be discussed. Based on the results of the unstructured interviews with education experts and AI researchers, transparency, justice, fairness, equity, non-maleficence, responsibility, and privacy are emphasized as guidelines for the use of AI in education. This study is a conception clarification of education teachers' ethics in AI courses. The results provide constructive directions for the use of AI in education (Yu & Yu, 2023).

2.2.1. Responsible Use of AI

AI in education is not novel; it has been used in the industry for years. The emergence of ChatGPT made it a hot topic in every discussion, including in schools, colleges, and universities. However, the definition of artificial intelligence by the OECD fictionalizes it as simply a computer program that mimics humans, such as ChatGPT and Snapchat AI (Zhou et al., 2020). It is essential to clarify AI as other forms of technology help explain what it handles and how it works. Classification helps approach it more easily. There are two types of AI. First, general-purpose AI is used in every field; for example, all organizations utilize speech, face, anomaly detection, and recommendation to understand audio and pictures and identify real data from fake ones. Second, generative AI is a subset of general AI and the more advanced one, which uses computational models to receive input and produce random outputs. For example, text generation, such as ChatGPT, and image generation, such as DALL-E2 and Stable Diffusion can produce pictures based on given text. Throughout these 50 years of development, general-purpose AI programs had given education a starting point (both good and bad) to make decisions and take actions on how future generative AI technologies must be handled. It also caused anxiety as it is super advanced, different, and more powerful than its predecessors.

There are three levels of understanding responsibility when it comes to responsible AI utilization. First, general understanding. This is the lowest level of understanding of AI and provides no information other than the given text by ChatGPT. Its responses always include an explanation of what AI is, what its capabilities are, and how it works without admitting its existence. It cannot write a proper critique of any content. This level of utilization is a black-boxed logic of "prompt-response." For example, if the prompt is asking what "Education must come first" means, it summarizes the definition of education, quoting, although not obviously, from itself and generating good points of the traditional meaning of education like schooling and learning to develop one (knowledge, skills, intellectual; as well as emotional, social abilities; moral education; and discipline).

Second is a naive understanding. Its responses include real content like logical arguments, or counterarguments, and sometimes data and numbers to support its statement; however, it is incoherent. To illustrate, if the prompt is asking students to write an argumentative essay under the title "Education must come first" in the "point, counterpoint and rebuttal" format, it generates complicated reasoning to develop points and counterpoints fully but forgets to include a rebuttal part. Third is a refined understanding. When it comes to generative AI, this is the highest level of understanding. An excellent critique is included, demonstrating real content and clear reasoning. It also understands that there are interests involved in the topic and that the "good" and "bad" judgment must be done based on the person's interests in the complications and multiple interpretations.

2.2.2. Fairness in AI Applications

A fair AI application captures the affordances of the ontological dimensions of the AI systems and the application context dimensions and accounts for inherent causal and computational variations across different contexts. Thus, entities relevant to the application context should be attended to in

the development of the AI application. In this light, AI systems responding to decisions requiring moral judgements should not adopt a one-size-fits-all approach but, with the context squarely in view, be adjusted with regard to relevant knowledge and values. The context dimensions in education include variables related to institutions, curricula, health and fitness, personal perceptions, backgrounds, ethics and pedagogy (Utterberg Modén et al., 2023). To gain traction in educational contexts and avoid the "formalism trap", effectiveness heuristics that embed human values need to be contextualised. Thus, educational implementations are pertinent to boost AI equity. Institutional frameworks, education policy and the values at stake must be specified to promote equity in each implementation context (Vuorikari, & Cabrera, 2020).

An equitable application of AI is grounded in an account of education, curriculum, student and school and how the AI system captures the context- and person-specific values distributed there. Dialogue in education implies accounting for student mattering. Thus, deep contextualisation includes representations as memory and actions in the structural and temporal dynamics of pedagogical agents, subject matter, developing students, curricular designs, tools, contexts and interplay across various time modes. Inter-contextual exploration of the causal structure of values is also needed to protect disadvantaged students from various forms of bias. AI models for effectivity and fairness become less powerful when predicting classes across contexts and require immense efforts to transfer training data across domains. AI fairness research synthesizes and contextualises insight from an equitable application of fairness heuristics in the development of AI models to promote educational equity.

2.2.3. Safeguarding Privacy

Teachers can harness AI to augment learning, but concerns about AI's impact on privacy have multiplied. The ability for AI systems to automatically observe and analyze student interactions with learning environments gives rise to a new level of concern about how student data is handled. While many traditional educational systems have prioritized privacy, AI systems collect and analyze student data in deeper and more intrusive ways than was previously possible. The increased power of AI systems necessitates a corresponding increase in accountability and vigilance about what is done with the data collected. UNESCO recommends Member States implement systems to safeguard privacy and security of student data. Similar frameworks, such as the General Principles of Artificial Intelligence Education (AIEd), are also in development. Implementation of such policies will require significant investment by institutions, as education systems now need to negotiate agreements with private companies and expect them to comply with various legal requirements (Latham & Goltz, 2019). Teachers need to advocate for these frameworks and work closely with institutions to see that they are properly implemented.

Because AI systems fundamentally alter the relationship a student has with learning, teachers must take care that they do not erode students' sense of control. Learning environments that present difficulties and failures to students are an important part of the growth process and help foster a positive relationship with learning as a whole. Teachers can do this in two complementary ways (Lam,2019). First, teachers can evaluate and select carefully solutions that augment rather than supplant their traditional role in deciding what information is relevant to the learning process and when it should be communicated to the student. Second, when they implement AI-powered learning solutions, teachers can be upfront about how much data is collected, what it is used for, and how it could be shared (Lakkaraju et al., 2024).

2.3. AI Foundations & Applications

AI Foundations & Applications is composed of four competencies: Conceptual understanding of AI systems, AI problem scoping, AI solution design and modelling, and Data ethics and responsibility. In this section, the rationale of incorporating AI Foundations and Applications in this framework is presented divided into two parts: Component Competencies and Rationale. The

component competencies are organized in six categories including, AI concepts, AI system components, AI technology, AI problem scoping, AI solution design and modelling, and data ethics. The rationale for the inclusion of AI Foundations and Applications in the framework is further elaborated in three parts: 1) It is defined by and widely accepted as a critical area of AI Competency; 2) It is up-to-date and contextualized knowledge of perceived AI competencies; 3) It is sufficiently researched, well-documented, and can be effectively used by the teachers.

The AI Concepts competency focuses on the definitions of AI, its association with computer sciences and statistics, and the differences among AI, machine learning, and deep learning. The AI System Components competency introduces the framework of AI systems to their planning, building, and assessment by using 12 components. The AI Technology competency includes knowledge of over 20 major AI tools and libraries to help their learning and development, as well as several recommended applications. The AI Problem Scoping competency emphasizes understanding the problem context, problem actors and stakeholders, and source of value creation before designing or implementing an AI system. The AI Solution Design and Modelling competency covers the traditional data processing and modelling of the knowledge graph and probabilistic programming depending on the needs. The Data Ethics and Responsibility competency includes eight key ethical questions of AI system design and implementation regarding data acquisition, model training, and result application, which are well-illustrated by relevant AI cases in biomedical development, privacy erasure, social media, and corruption recognition. (Chiu et al., 2024)

Competency Matrix is designed as a visualized and static resource and a reference for teachers and educators to determine their students' learning stages on AI based on their curriculum/syllabus. It is formatted as a matrix including between three and five levels of proficiency of each competency category elaborated by clear explanations and expected outcomes, targeting primarily at teachers as the audience. Considering the scarcity of AI education research in the context of the Chinese K-12 education system , this prototype design is expected to help educators to systematically identify strengths and weaknesses of their existing AI education practice on K-12 AI competency cultivation.

2.3.1. Understanding AI Principles

Section content includes, but is not limited to: university teaching-learning situations; higher education system; use of technology; mobile technology; cloud computing; and open educational resources (OER). These emerging educational trends are often referred to as Web 2.0 educational applications or cloud education. Such new information technologies are reshaping educational philosophies, approaches, and models within the university context. Built upon an open education foundation, cloud education drives university educational reform by significantly altering management, teaching, learning, and assessment methods.

The opportunities presented by these new trends can be viewed from three perspectives: dramatically reducing costs and barriers for university education; raising aspirations and requirements for the future of higher education; and expanding access and fostering wider distribution from local to global educational networks. Despite these positive trends, traditional evaluation methods, such as rote memorization assessments, continue to dominate university education systems in many countries. Consequently, university students often lack opportunities to engage with or apply new technological innovations for meaningful and productive learning. In this regard, the pedagogical gaps between the ideal and the actual university education models have become increasingly pronounced.

In addition to the general transformation opportunities presented by evolving teaching and

learning practices, universities also face implementation challenges, including significant pedagogical gaps in AI literacy education and a lack of resource options. AI education emerges as both a major challenge and a tremendous opportunity for lifelong learning in higher education. AI algorithms serve as the central drivers of various educational applications designed for personalized learning experiences. The equity and fairness inherent in these AI-driven educational algorithms are essential components of effective AI education. Therefore, it is vital to integrate comprehensive AI literacy education into the core of university curricula. (Zhou et al., 2020)

2.3.2. Technical Literacy in AI Tools

The introduction of artificial intelligence (AI) technologies offers new opportunities and challenges for education, thus raising the need to clarify the goals of AI education and how to best support it. AI literacy is increasingly recognized as an important area of education relevant to all levels of education and ways of life. It is defined here as feeling in control of and actively engaging with AI technologies (Zhou et al., 2020). To address these issues, bottom-up efforts to design AI learning experiences across different education levels and domains should be supported by frameworks that clarify the depth and breadth of desired learning outcomes. For AI literacy to have a sizeable impact on education, more theoretical grounding is also needed, for instance understanding how to best motivate educators to take on the often steep learning curve required to effectively approach AI learning experiences. Furthermore, there is a need to raise awareness about how AI tools and platforms embed audio-driven principles in order for educators to know how to best create AI learning experiences.

2.3.3. Real-World Applications of AI

Some examples include gauging the effectiveness of the top three search engines with AI-generated prompts, testing AI writing apps by assigning experimental, social, or ethical questions, examining the options one-by-one for accuracy and relevancy, assessing misinformation and deep-fake generation on widely available apps, and designing a DiploHack around mitigating AI, data abuse, or misinformation spread. Other suggested applications include exploring AI apps for language learning, speech generation, story-writing, coding, photo editing and generation, VR manipulation, game designing, mind-mapping abstraction, problem-solving, and productivity assistance. Students are also encouraged to assess capabilities of AI tools for preparing and responding to conferences and debate prompts, materials development, class scheduling, travel planning, etc., involving one facet of ASOL (e.g., research, advertisement/presentation, demonstration, or entertainment) by different tools (Aliabadi et al., 2023). While there are concerns about misusing available AI tools in proctored high-stakes exams, it is argued that proctored exams are already known to motivate avoidance and mechanical knowledge transfer. With educators being the desired compliance force for exam systems, it is important to consider their intended educational purposes. Institutions generating these exams must ask themselves why they are causing stress, chaos, and credit transfer to be a higher value among other beliefs. Together, those interested in learning through compliance must make exams more relevant to learners' pursuits, interests, and frequently used assessment quality standards. Such changes would foster students' long-term motivation to demonstrate their learning, acquire stronger merits, and delight in the wondering journey of knowledge.

Broader public conduct of AI and ideated guide questions stem from an assessment of the AI facades that perplex and solicit concerns, wonder, and disputation among younger generations. Suggestions include brainstorming a lesser-known or unintentional AI equivalent for the major apps on their phones, searching this AI's prompt on their devices, curiosity's fuel attendance or absence in their surroundings, automatic personal agency or information control, medium quality control, and accountability identifying, relevant mind-hacking programming potential, searching,

responded, and social perceptions owned or orchestrated by them. AI's ownership or interpretation of the history and social dynamics regarding a publicized event or conduct is among the other guide questions. Although all students are different and favorable attention must be given to individual differences, the focus should be on the very known, concrete, nearby, and age-appropriate contexts of mental quality control.

2.4. AI Pedagogy

Pedagogy is the deep-seated convictions about how to understand and convey knowledge or know-how, how people learn, what meaningful knowledge or know-how is, what understanding of knowledge or know-how looks like, and what kind of environments and experiences encourage learning. Pedagogical beliefs and practices ultimately affect technology implementation and user adoption. AI pedagogical beliefs encompass the epistemological, ontological, and sociocultural fundamental underpinnings about understanding and conveying intelligible, learned, performable, and enacted data-based algorithms, processes, and systems. Those with more expansive AI pedagogical beliefs are more apt to engage in immediate, exploratory and cognitive AI activities, as well as long-term AI experiences. Along with general pedagogical beliefs, transformational and expansive AI pedagogical beliefs further lead to AI-enhanced learning and assessment experiences. Effecting and influential pedagogical beliefs can and should also be transdisciplinary and culturally relevant. In contrast, AI pedagogical content beliefs specify the knowledge, know-how, supports, and constraints about conveying and framing intelligible, learned, performable, and enacted data-based algorithms, processes, and systems in AI-delivery for teacher professional development. AI pedagogical content knowledge frames the amalgamation of AI pedagogical beliefs and AI teaching strategies that modify, adopt, or design AI-delivery pedagogies for enacting teacher professional development. In transdisciplinary, culturally relevant, and other low-power cultural settings, collective agency should reach beyond the individual abilities, motivations and familiarity frameworks of boundary element analysts when preparing, do and obsolescing new AI-capable teachers. Understanding emergent teches foregrounded by boundary actors were deployed and help frame moves across boundaries - rustic, inexplicable fashions of use, taking distinctly deliberative forms by brokering, working, and sharing appreciation, contemplation and question-building on pedagogically-adopting, aware engendered technology. They enact phenomenon framing of unclear teches by teachers' boundaries, maintenance of prefigure of purposed learning, intertwining of inquiry and recognition, and provision of space and time for sensorial engagement.

2.4.1. Leveraging AI for Lesson Planning

Teachers can leverage generative AI tools to assist with lesson creation and educational material design. For example, to explore how to teach an AI topic such as search engines in a science lesson, teachers can input prompts and specify parameters such as grade level and learning objectives to generate a first draft lesson structure. Once results are produced, they can be reviewed and adapted to match the local educational context. These tools can also generate various types of content, including PowerPoint presentations, student handouts, research questions, and recommended readings, which educators can integrate into cohesive instructional activities. Generative AI systems therefore support the development of high-quality learning materials or provide preliminary drafts that teachers can refine through iterative processes. However, educators must provide clear contextual inputs, critically evaluate outputs, and verify information accuracy, particularly given the potential for AI systems to generate misleading or fabricated content (Van Brummelen & Lin, 2020).

AI tools are increasingly used to support teachers in traditional instructional roles, particularly in tasks such as lesson planning, content development, and classroom management. These technologies enable educators to generate initial drafts of teaching materials, adapt content to

diverse learning levels, and streamline administrative processes. As a result, teachers can allocate more time to meaningful pedagogical interaction and student support. In this context, recent research highlights how AI can enhance teaching efficiency while preserving the central role of the educator in the learning process, reinforcing the idea that AI should function as a complementary tool rather than a substitute for human instruction (Fernández Jiménez, 2024).

Furthermore, teachers can employ generative AI to produce educational content tailored to student language and comprehension levels, thereby fostering more engaging and accessible learning environments. These tools also enable the development of innovative training formats that combine personalization with scalability at relatively low cost. For instance, generative text-to-image systems allow users to design visual materials by refining prompts, facilitating both creativity and critical evaluation of AI-generated outputs. As immersive technologies such as extended reality (XR) environments continue to evolve, educators are required to develop ethical AI literacy, increase responsible usage, and address misconceptions related to AI-generated content. This approach contributes to preparing students as informed and responsible digital citizens, capable of critically engaging with AI technologies and their societal implications.

2.4.2. Personalized Learning through AI

With educational and business practices becoming more siloed, the notion of learning communities, spaces founded on the collaborative sharing of knowledge and insights, is becoming increasingly important in an era of information overload (August &Tsaima, 2021). The stresses of the COVID-19 pandemic are evolving society into a period of rapid change, presenting significant challenges and opportunities as the processes of living, working, learning, and teaching are irrevocably altered at the societal scale. The ability to navigate complexity bouncing between remote and physically present communities is essential under the circumstances. This understanding speaks to the broader understanding of structural forms across levels of social interaction, the canonization of these forms through social institutions, and the flexibility of understanding regarding interpretations and responses to these social structures. With the goal of deeper learning for all individuals, districts, and institutions, a co-development framework is presented as a means of historically informing a future designed model for multi-level understanding and resilience in learning communities and smart schooling practices.

Fantastic new adaptive educational systems are expected to be able to measure a student's knowledge state, predict the bounds of the knowledge state, compare learning actions and their predicted effects in order to select a relevant action, and make adjustments to instructional parameters in order to broaden the bounds of the student's knowledge state (Lam, 2019). Predictive systems for learning generally begin by estimating the learner's performance on a future question, selecting an optimal question from a set of possibilities, presenting that question, measuring the student's efficacy on the question, and then choosing suitable module parameters to maximize effectiveness on the subsequent question.

2.4.3. Integrating AI in the Classroom

Artificial Intelligence (AI) technologies are integrated into its new curriculum from AI literature studies to AI-based Makey Makey activities. AI education ought to be transdisciplinary, including connections to the broad curriculum and community in which learners are learning. Hence, approaches for developing a transdisciplinary AI curriculum, including themes, connections, and real-world problems, are based on the designed frameworks. In response to Saudi Arabia's Vision 2030, the advancement of Artificial Intelligence (AI) across various industries is of utmost importance. In line with this ambition, dangers and risks related to the development of AI must be accounted for as well (Aliabadi et al., 2023). Additionally, the education system undergoes a radical change in this context, including in K-12 schools, and aims to one day be globally recognized. A new educational ecosystem is designed to produce future-ready graduates. This system includes

the Neom Community School which offers an innovative approach to the educational experience. Key aspects of the school's educational ecosystem include curricula emphasizing Whole-Student Transdisciplinary Outcomes, such as Humanities, Social, Emotional, Cognitive, and Physical, Engagement with the surrounding environment, Unique and engaging Units of Inquiry, and Value-driven community. Co-design is undertaken with the participation of the members and community of the school.

The core curriculum in use employs the Inquiry-Based Learning (IBL) pedagogy, integrated with the International Baccalaureate (IB) principles and guidelines. The integration of AI into this curriculum attracts attention, especially considering the rise of generative AI and also the teachers' and students' struggles with it. Consequently, the AI literacy of both teachers and students is taken into account in the student curriculum. This goes past digital literacy and emphasizes understanding the socio-technical aspects, which are both fundamental and also challenging as AI is often not understandable. Hence, the integration of AI literacy into education is thoroughly researched and a framework is initially adapted.

2.5. AI for Professional Development

The competency framework described in this document can be used to inform educators' professional development; countries' educational policies; and the design of teachers' digital learning resources. If countries wish to roll out a national policy and training to integrate AI into education, the Global Framework can guide national strategies. Given some of the inherent challenges of designing competencies for an international audience, a second goal is to inform countries as they begin developing their own national frameworks. A framework for designing digital tools to support teachers is presented. (Zhou et al., 2020).

Central to UNESCO's Global Framework are five key competencies for teachers as they integrate AI in education. There is significant interest and development happening in this area globally; hence, it is important to have a comprehensive understanding of the landscape. The Global Framework is not prescriptive but is designed to guide national development of frameworks relevant to their own contexts. It outlines the importance of these competencies, examples of initiatives related to each, and an accompanying set of critical questions to consider in the development of national frameworks. (Chan, 2023)

Countries have a variety of responsibilities and options to consider that will form their overall education policy and strategy. National development of the suggested Global Framework's competencies is a vital avenue for scaling up AI for education. There are many considerations in doing so and a lot of work is required; however, the iconic examples in the Global Framework should provide considerable stimulus, encouragement, and inspiration to undertake the necessary work. Supported by expertise, accurate information about AI, and continuously updated policy on safety and effectiveness. AI tools can provide a list of personalised, tailored resources. (Mattar et al., 2022)

2.5.1. Using AI Tools for Self-Learning

Supporting teachers in the field of AI is a prerequisite to realizing an AI-competent society by ensuring that teachers can interact with AI. ChatGPT is an AI tool that influences learning and teaching. To promote teachers' understanding and awareness of this technology, and at the same time to investigate beyond the immediate impact of its developments, a self-study approach was used. This approach consists of a design view on how to guide self-study, alongside with a performance view to critically evaluate the engagement with the technology in retrospect. A design process was iteratively performed by formulating a learning goal for using ChatGPT, tailoring a prompt as an argumentative text-stimulus and reflection tool for self-study, accompanying the

reflection with guiding questions, and exploring the results of the self-study within a larger community of inquiry who engaged with the same self-study design. A practical use case is presented that can help educators prepare for the uncertain and open future with AI technologies, and the design and performance view can guide self-studies on other AI tools by comparing the specifics of technologies and contexts (Zhou et al., 2020). The extravagant advances in artificial intelligence (AI) create much hope and concerns in society and the newly emerged AI capabilities almost immediately drive up speculation on how they implicate education and learning. Teachers are set to play a vital role to realize an envisioned positive vision of AI, whereas concerns arise about how teachers learn to understand and be aware of AI tools and their implications beyond superficial interactions with the technology. Following formative assessment and formative interventions, the formative speculation framework is structured as the intention for theorizing and guiding self-study on using AI tools to influence awareness and understanding of AI and its potential implications on teaching and learning in an educational setting and beyond. This theory aims to be practical and generative to explore new later stages of AI technologies. (Ng et al., 2023)

2.5.2. Instructional Growth through AI

Traditional AI education initiatives often carved AI out and taught it in discrete lessons or units. Students would be taught AI competencies separately from or on top of learning about data science, ecology, or English. While such complementary form of curriculum is better than uncritically adopting AI tools, complementary AI education still has the conception of a "thing" to teach situated outside the other content of learning (Yan, Sihes, & Zhang, 2023). Therefore, the focus was still on developing a standalone conception or lesson plan on AI, like the quest for a unicorn in the woods or a golden goose on a faraway island. AI education in the complementary style of learning not only left the other educators out of the conversation due to the imbalance of expertise, but it did not even pique their curiosity in the potential of AI education. On the contrary, AI instruction transcended mere interdisciplinary teaching. (Kim et al., 2022)

The term interdisciplinary has historically been a term of education policy with many understandings and implementations. The concept typically refers to learning outcomes that integrate the learning about multiple concepts into a lesson or series of lessons . Students in an interdisciplinary AI ecology unit plan AI as a mechanism similar to the concept of animal classification and then propose to create a machine learning system that classifies invasive plant species. This understanding of AI as a mechanism is multi-faceted and draws from multiple disciplines. In this sense, students are learning two disciplines through their study of AI and ecology. However, the model of AI education piloted by NCS and rooted in the International Baccalaureate® (IB) Program was transdisciplinary. (Southworth et al., 2023)

Transdisciplinary suggests not just the combination of two disciplines but efforts that move beyond discipline-specific solutions. An ecological problem in and of itself does not need to remain solely an ecological problem. As has been noted, problems in ecology did not arise solely thanks to a lack of ecology. Researchers representing the wide spectrum of human abilities and intellectual pursuits can combine their skills and understanding to solve problems unsolvable solely by the discipline in question. This redirection of thinking regarding how to teach AI challenges deep-seated conceptions of subject division and obligations, as many educators involuntarily focus on preserving set domains of knowledge and expertise and feel obligated to justify why something other than their subject should be taught. (Lawrence et al., 2022)

2.5.3. Continuous Professional Development

Teachers and educators experience pedagogical, methodological, and technological changes throughout their working lives. They must be provided with opportunities to engage in continuous professional development (CPD) that leads to improvements in their education, qualifications, performance, experience, and motivation. The CPD curriculum should include the use of

innovative technologies as a portal to more advanced technologies, techniques, and practices, as well as the upgrading of knowledge and qualifications to the next higher degree, diploma, or certificate, or to a specialist degree. (Zhang et al., 2021)

The AI Competency Framework for Teachers is a capacity development tool that bulks up competency frameworks from other organizations and governments and contextualizes them for AI in education and ICT integration. Its three components are competency domains, levels, and enablers(Vuorikari, & Cabrera, 2020). Competency domains represent the areas of knowledge and practice teachers, student teachers, and educators are encouraged to develop and apply in their work. They define the scope of the competency framework and describe its relevance across all education system levels. Competency levels suggest milestones of professional development, indicating the degree or depth of knowledge or practice defined for a specific competency domain and enabling transversal competencies to reach higher competency levels. Enablers identify the conditions that facilitate or trigger professional development efforts across the education system (Desta et al., 2013).

This section identifies ways to provide teachers and educators with CPD opportunities to develop competencies defined in the AI Competency Framework for Teachers. The competencies are organized according to four teacher competency domains drawn from the framework and expanded to fit in-country contexts, and corresponding actions for key stakeholders are suggested. Curricular, pedagogical, infrastructural, and community measures are elaborated in recommendations to be applied at priority education levels. Implementers are invited to adapt the recommendations to fit local resource availability and capacity. (Antera, 2021)

2.6. Challenges in Implementing AI Competencies

There has been a growing demand for university educators to design AI learning experiences, particularly as many national governments and local educational authorities have been increasingly advocating for AI education at the university level in recent years. As a result, numerous initiatives have produced a wide array of university-level AI learning resources, including comprehensive AI curricula, specialized AI courses, and engaging AI workshops and platforms. Furthermore, in light of the rapid advancements in AI technologies, many research institutions have expressed interest and allocated resources to explore the development of university-level AI education. Most of these efforts are directed towards refining curriculum content, with an emphasis on creating effective AI courses that encompass various dimensions of AI literacy.

To ensure that more intricate systems function as intended, enhanced mechanisms for dialogue, strategic planning, and the execution of complex systems are necessary. Additionally, these systems would benefit from the ability to communicate more naturally as they expand their capabilities. There are also opportunities for collaboration with external stakeholders, including non-governmental organizations (NGOs), to partner with educational institutions and engage in the growth of innovative industries. This collaboration inevitably brings forth a variety of ethical challenges, which extend beyond the typical concerns associated with emerging technologies. Consequently, these issues warrant further public discussion to address the implications of AI in academia.

Moreover, regulation poses another significant challenge for the integration of AI into educational practices. In many instances, particularly those involving sensitive student data, the use of AI represents a novel approach that is not adequately addressed within existing regulatory frameworks. This raises critical questions: Will AI lead to more equitable and informed decision-making compared to traditional methods? Will educational institutions transform into opaque

entities, hindered in terms of transparency regarding their decision-making processes? Can the decisions made by AI systems be deemed reliable, and what new methods for establishing trustworthy AI are likely to emerge in this evolving landscape? (Zhou et al., 2020)

2.6.1. Barriers to Adoption

Despite the numerous benefits associated with ICT adoption, there remain various barriers that hinder the advancement of ICT use in educational practice. Previous studies have identified a number of barriers related to malfunctioning equipment, application software incompatibility with existing hardware, high maintenance costs, bureaucratic inertia, and ineffective administrative policies. Some of those barriers are without dispute, while others are relevant in some countries and irrelevant in others. Barriers also vary depending on the specific application of ICT. It is therefore important to first understand the barriers to new technology adoption on a more general theoretical level before examining specific barriers related to a particular technology.

There are at least two sets of barriers to ICT adoption in education. The first set consists of technological barriers that can be categorized as external barriers. This set includes the inadequacy of technology and skills, the limited flexibility of preset educational programs, the unreliability of software, insufficient funding, and constraints imposed by media institutions and telecommunication companies. The second set is pedagogical barriers that represent internal barriers to ICT adoption. They concern issues such as lack of individual understanding of teaching and learning, lack of knowledge and pedagogical capabilities in properly adopting new media in existing educational paradigms, and a lack of innovative assessment and evaluation.

Technology adoption is inevitably resisted by teachers who are not prepared for the pedagogical implications of new technologies. Those teachers remain digital immigrants who, though well acquainted with the technologies of Web 1.0, find themselves out of their depth in the new digital landscape of Web 2.0 and beyond. Some teachers display apprehension plus an aloof attitude, believing the new technologies to be an unnecessary disruption of their work and an added risk (but not value) to the teachinglearning process. Thus, barriers affecting pre-university ICT adoption also contain pedagogical aspects focused on explaining existing behaviour that is resistant to change (Wiziack& dos Santos, 2021). Public authorities must therefore take greater responsibility in leading educational reform processes, clarify their visions for schools, commit to more proactive, supportive policy measures and interventions, and ultimately communicate effectively and follow through on their plans.

2.6.2. Addressing Teacher Concerns

The large number of teachers predicted to leave the profession poses a significant challenge that many countries are anxious to address. This is even more urgent now that many teacher candidates are likely to withdraw from teaching or training altogether during a period of unprecedented economic uncertainty, an additional layer of complexity in the scramble to recruit and train new teachers. Despite efforts in many countries to recruit teachers, retention remains challenging. The general feeding and flowing of teachers into and out of the profession has led to any improvements and optimism around teaching in light of progressions such as the pandemic often evaporating overnight, leaving schools scrambling to find and train the many thousands of teachers lost.

Teacher burnout and anxiety are more persistently evident now than prior to 2020, with many worldwide reporting feeling less valued and respected. This comes at a time when other professions, such as policing, nursing, and hospitality, now have contract offers at a level that in combination with economic factors make them more appealing options as career choices. It is also at a time of urgent demand for a more effectively and efficiently prepared, equipped, and developed teaching workforce. Such recruitment and preparation needs must be undertaken in a context of amplified anxiety about potential inequities, with the necessity of addressing the

challenges of recruitment, preparation, deployment, retention, and development of the teaching workforce needing to be addressed.

Unprecedented teacher and trainee teacher burnout, anxiety, and erosion of morale are evident in many countries. Teacher rectitude is eroded by a growing sense that the teaching profession is devalued, with the great public good that the teaching profession brings to the life of their communities and society now less widely recognised. An analysis of the discourse around technology in education suggests a growing alienation from other sectors with much greater investment, capacity development, and commitment to produce quick win measurement. If not addressed, a tragic and wide-scale collapse of a generation of apprentices, trainees, and teachers looms. There is an urgent need for the workforce to be better prepared, supported, and developed in regard to more effective use of technology. Absent a more systematic focus on accessible and affordable evidence-informed professional learning and practice, actions will remain individual and piecemeal.

2.7. Future Directions

Prediction of near-future developments and possible scenarios (with a selected timeframe) takes into account demographic, educational, technological, societal, political, and environmental factors. The aim is to identify factors that can potentially influence future trends in the teaching profession with regard to emerging technologies. Education systems and respect for schools, teachers, and learning professionals are expected to be affected by important demographic shifts in the coming decades. Population and labour market shifts and associated migration patterns, for instance, have implications for education systems (RIINA et al., 2020). Changes in the structures of the populations put pressure on educational systems to transform and adapt curricula and pedagogies. Elderly people being more prevalent raises questions about preparing society to manage and engage with ageing populations. Corruption and greed cause young generations to become disenchanted with the current political status quo, demanding more open and transparent authorities and institutions, and joint ownership of the planet. Children and youths care about the Earth and the environment. A great share of these generations is proactive, taking steps to ensure actions and measures to save the environment. Manipulative uses of technologies can easily jeopardise the environment. In non-democratic regimes, education methods constrain citizens' possibilities to communicate and share thoughts and opinions globally, even within their own countries.

Emerging technologies have a rapid pace of development, and they are proliferating and expanding into new sectors and communities as solutions to tasks in everyone's everyday life. Artificial Intelligence (AI) has started to influence traditional education and learning practices. It enhances, augment, and automates actions of educators, learners, and educational institutions. This promises improved learning outcomes, a more tailored education, and a massive increase in the efficiency of education systems. Efforts are directed towards developing assistive and augmentative technologies, and systems enabling direct sensing and capturing of behaviours, comprehension, and emotions. These blended analytical and acting systems close the loop, promising instant feedback on the actions for everyone. Technologies also expand learning opportunities and possibilities to access education globally. However, emergent technologies create social implications, such as a digital divide, increasing inequalities and urgency in dealing with data privacy issues and concerns about AI systems acting against human intentions. They raise ethical concerns: how accountable, explainable, transparent, and fair to all are AI systems? How subjective is data collection, information processing, and actions taken based on this? The expectancies of safeguarding against dangers associated with the use of technologies contradictively raise fears of ineffectiveness and inefficiencies of establishments and authorities. Control of the future is a fear for many, posing a challenge to political systems and democracy.

2.7.1. Evolving AI Technologies

AI technologies have evolved rapidly, and we interact with them in our daily lives for personal or professional use (Zhou et al., 2020). There is an increasing focus on integrating AI into pedagogy, yet a limited understanding of its implications remains. Important ethical, pedagogical, and teaching-related questions create interesting opportunities for educators, and there is a social responsibility to ensure the appropriate use of such technologies in teaching and learning. AI has already made strides in replacing traditionally human tasks like writing essays and computer programming. The competing, large language models developed just this year had conversational capabilities that no teacher was fully prepared for; countless classrooms around the world were disrupted by students using chatbots, causing teachers to rethink and revise their curriculum. Although shocking, such occurrences are somewhat expected as technological advances invariably outpace teaching and learning. The COVID-19 pandemic led to an explosion of new technologies implemented in education settings, but few teachers or institutions had comprehensive strategies for incorporating live-streaming tools into their program. Overall, several issues cause an inherent expectation that educational institutions should be slower to change than the pace of development in the world around them. Researchers and educators need to adapt to this quickly changing environment to leverage the transformative power of AI technologies while avoiding their detrimental effects. Unifying concepts contribute a public forum for discussing and refining a common language surrounding the implications of generative technologies for education. It articulates a set of big ideas that allows educators to begin explaining and exploring generative technology's implications for teaching, learning, and well-being. These concepts help provide the groundwork for pedagogical approaches to generative technology, contributing to the idea of AI literacy technologies. Such a foundation is essential for ensuring society uses these technologies to enhance rather than undermine human potential and promotes collaboration, dialogue, and information sharing by providing authentic, shared language, concepts, and frameworks.

2.7.2. Implications for Teacher Training

The introduction of new information and communication technologies (ICT) in schools is a demanding public policy challenge for all countries. The participatory approach in SELFiE gives a voice to the key local stakeholders involved in the learning process, including teachers and school leaders. Furthermore, the results serve as valuable input for the development of new initiatives, like national plans and training opportunities, for teaching with technology. In fact, it is often stated that a teacher’s digital competence is the most crucial factor for successful ICT integration in schools. If teachers are not competent to effectively use ICT in their teaching, any investment in internet access, computers and software is seen as unproductive.

Large-scale international approaches highlight the need for national strategies to improve teachers’ digital competence. In a growing number of countries, these strategies are already in place, supported by initiatives from different stakeholders. However, the desired enhancements of teachers’ digital competence, the strategies and initiatives applied to support this goal, and the perceived bottlenecks of these initiatives seem to differ between countries and regions. Hence, the context matters substantially. Indeed, the strategies and initiatives to support the professionalization of teachers’ digital competence can be rooted in different models of teaching with technology (Tejada Fernández & Pozos Pérez, 2018). Given the central role of teachers in any approach to provide their competencies in teaching with technology, it is essential to investigate the status quo of their digital competence, the support provided for the further professionalization of this competence, and the perceived bottlenecks. With an eye on SELFiE a series of scoping studies was undertaken in various countries to map the local situation regarding the professionalization of teachers’ digital competence (Mohamed Manik et al., 2014).

In first place, the overall objective of the scoping studies was to (1) outline teachers' digital competences; (2) map strategies and initiatives to improve these competences; and (3) identify bottlenecks encountered in these initiatives to broaden the international understanding of teachers' digital competence (TDC) with an aim to improve technology integration in education worldwide. Secondly, this is seen as a core contribution to the design of the international SELFiE initiative, initially especially regarding its framing functions. Ultimately, the scoping studies were expected to inform the next steps of the initiative, including how to present the results of the self-assessment, how to invite stakeholders to take up the results, and what kind of follow-up actions to initiate and sustain the process of TDC improvement.

3. Methodology

The growing integration of **Artificial Intelligence (AI)** in **teacher education in Higher Education (HE)** has triggered significant advances in research on **AI Competency Frameworks for** teachers (Cukurova et al., 2024).

This scientific article presents a **systematic review** (Marín, 2022), conducted according to the **PRISMA 2020 protocol** (Page et al., 2021; Yepes-Nuñez et al., 2021), together with specific guidance from the **PRISMA-ScR** extension for exploratory reviews (Tricco et al., 2018), and the **PRISMA-S** extension for literature searches (Rethlefsen et al., 2021). The **PRISMA-P protocol** (Moher et al., 2015) was used in the planning phase.

To ensure the representativeness of the articles selected for this study, we followed the steps suggested by Page *et al*., 2021, who recommend the use of the PRISMA methodology for systematic literature reviews, as shown in **Table 1.**

Table 1.

Prisma Methodology Process

Phase	Articles
Recordsidentified (4 queries + dimensions)	201
After removingduplicates	150
Title/abstract screening exclusions	120
Full-textassessed	30
Final articlesincluded in synthesis	**12**

Source: own elaboration (2025)

The **databases used**were:**Google Scholar**, **Web of Science (WoS)**, **Scopus**, **Springer**, **Wiley**, **Frontiers**, **Elsevier**, and **MDPI**, covering documents from **2017 to June 2025**. Searches were conducted in **English**, and eligibility criteria included **primary studies on ICT and new AI applications in teacher education in HE**, specifically aligned with the **UNESCO AI Competency Framework** or its five dimensions:

The very first step in conducting the study was to carefully identify the specific articles that would be included in the overall research.To accomplish this, a detailed **keyword search** was carried out in highly regarded academic databases: **Web of Science**, **Scopus**, and complementary sources (**Google Scholar**, **Springer**, **Wiley**, **Frontiers**, **Elsevier**, **MDPI**). covering documents from **2017 to June 2025**.

Searches were conducted in **English**, and eligibility criteria included **primary studies on ICT and new AI applications in teacher education in HE**, specifically aligned with the **UNESCO AI Competency Framework** or its five dimensions:

- **Human-centredmindset**
- **Ethicsof AI**
- **AI foundations&applications**
- **AI pedagogy**
- **AI forprofessionaldevelopment**

These databases are widely recognized for their importance in **systematic reviews** and **bibliometric analysis**, making them the ideal choice for this research endeavor. The search outputs from these databases were intelligently combine dusing various **database operators**, ensuring a wide and diverse array of results.

To refine the search process further, specific inclusion criteria were established that required the presence of the selected keywords in the"**Title,**" "**Abstract,**" **or** "**Keywords**" sections of the articles being examined.

The detailed **Search Queries** used in this process were:

1 **UNESCO AI competencies + Teachers / University**

2 **AI teachercompetencies + HE**

3"**AI competencyframework" + universityteachers + UNESCO**

4"**AI competencyframework" + HE**

Searches across the five **dimensions** of the UNESCO framework. As a result this **initial comprehensive search**, a total of **201 papers** were retrieved and documented for further analysis. **Table 2** presents the inclusion and exclusion criteria used in the selection of studies, based on publication type, educational level, framework reference, subject focus, language, period, and source.

Table 2.

Search and inclusion/exclusion criteria

Criterion	Inclusion	Exclusion
Publicationtype	Peer-reviewedarticles	Blogs, press, non-academic
Educationallevel	University / HigherEducation (HE)	K-12 only
Framework reference	UNESCO AI Competency Framework oritsdimensions	Generic AI in education; no teacherfocus
Subject	AI teachercompetencies	Purelytechnical AI; no educationalapplication
Language	English	Otherlanguages
Period	2017–June 2025	Outside date range

Source: Own elaboration, June 2025

4. Results

The main lines of productivity

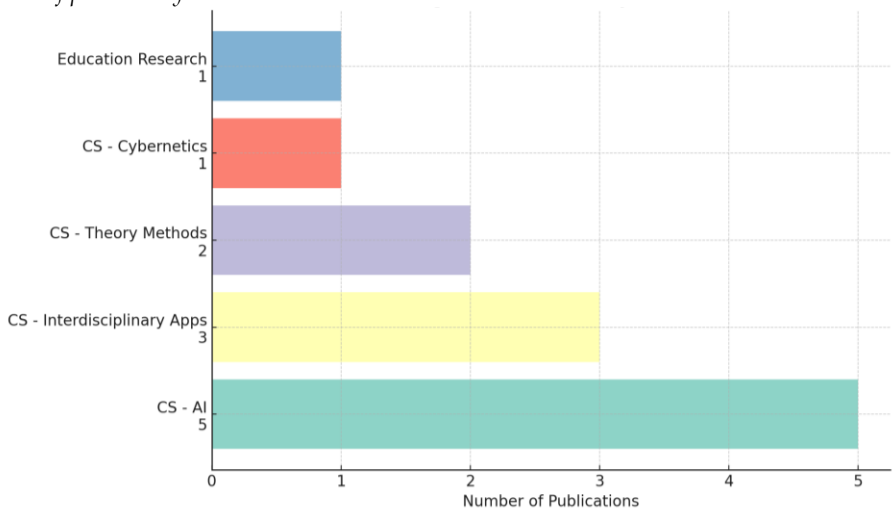
Figure 1 presents the classification of the 12 selected articles according to their main disciplinary categories. The field of *Computer Science – Artificial Intelligence* stands out with **5 publications**, followed by *Computer Science – Interdisciplinary Applications* with **3 articles**, and *Computer Science – Theory & Methods* with **2 articles**. Areas directly related to **Education** and **Ethics** account for only one article each.

These data reflect a clear predominance of technical and computational perspectives in current academic production. While this focus highlights the foundational role of technology in shaping AI applications for education, it also reveals a significant underrepresentation of pedagogical

research and ethical frameworks. As such, there is an evident opportunity—and need—for more contributions from the field of **educational sciences** to balance the current bias and explore how AI tools intersect with teacher development, curriculum design, and learning personalization.

Figure 1.

Lines of productivity



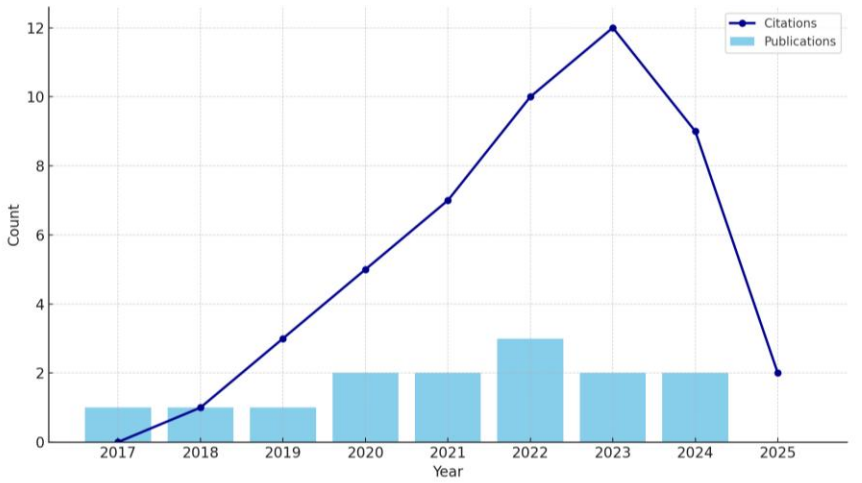
Source: Own elaboration (2025)

Productivity of the articles

Figure 2 illustrates the temporal evolution of publications and citations, highlighting a steady increase in scholarly attention to the topic. Between 2017 and 2020, research output remained limited, with only one publication per year. However, from 2021 onwards, a clear upward trend is observed. The highest level of productivity was reached in 2023, coinciding with pre-launch activities related to the UNESCO AI Competency Framework, which may indicate a link between institutional initiatives and research output. A similar pattern is evident in citation trends, which also peak in 2023. This suggests that studies published between 2021 and 2022 are gaining greater visibility and recognition, reflecting a consolidation of academic interest in the field.

Figure 2.

Publications and citations



Source: Own elaboration (2025)

Productivity by journals

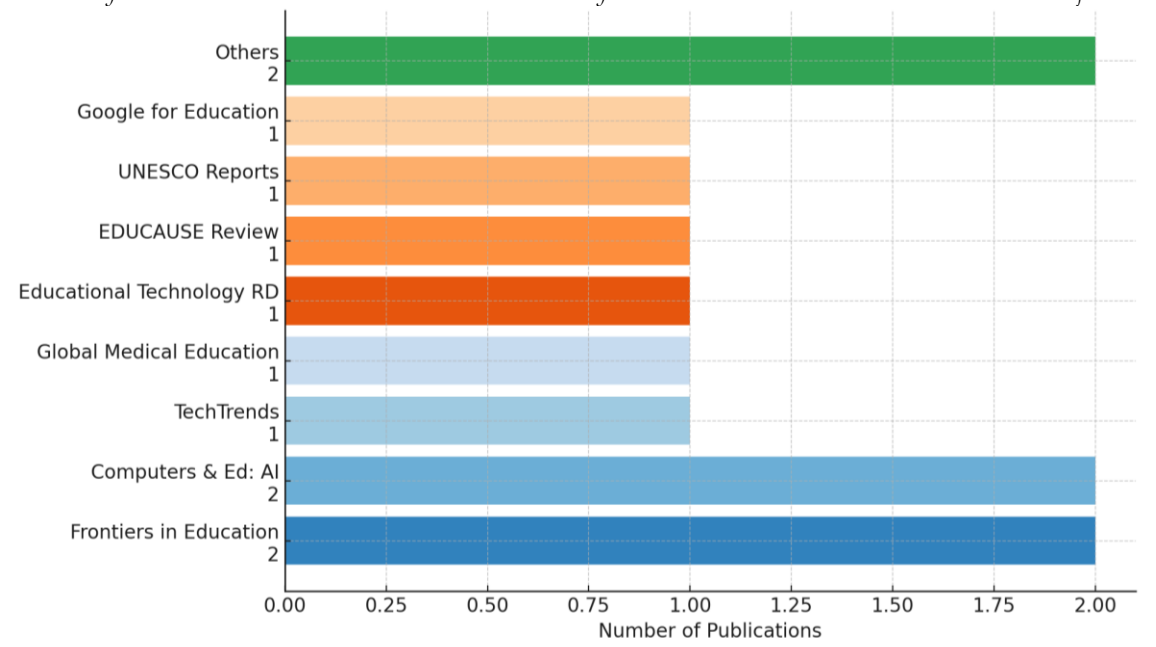
Figure 3 presents the distribution of the 12 reviewed articles by journal or platform. The journals with the highest number of contributions are Frontiers in Education and Computers & Education: Artificial Intelligence, each with two publications. Other journals, including TechTrends, Global Medical Education, and Educational Technology Research and Development, contributed one article each.

In addition, three articles originate from institutional or grey literature sources, such as UNESCO, EDUCAUSE Review, and Google for Education. Although these sources are not strictly peer-reviewed, they provide high-impact frameworks and are widely cited.

This distribution highlights the interdisciplinary nature of the topic, with contributions spanning both technology-oriented and education-focused journals. It also underscores the significant role of international organizations in shaping the discourse and facilitating knowledge dissemination.

Figure 3.

Productivity by journals



Source: Own elaboration (2025)

Productivity by authors

Table 3 presents the authorship patterns across the 12 selected articles. These publications were produced by a total of 12 authors or author teams, indicating that each article was written by a different contributor. This distribution suggests that the field is still in an emerging phase, with contributions arising from relatively isolated initiatives rather than from well-established research groups.

Only two authors—Bai and Ren—appear more than once in the dataset. Their repeated contributions reflect early efforts to establish continuity and depth in research on AI-related teacher competencies within higher education.

The following table highlights the most prolific authors:

Table 3.

The most prolific authors

Authors	**Numberofarticlesthathavebeensigned**
Bai	2
Ren	2
Vorobyeva	1
McGrath et al.	1
UNESCO (institutional)	1
EDUCAUSE (institutional)	1
Google forEducation	1
Chan	1
Ng et al.	1
Aliabadi et al.	1

Source: Own elaboration (2025)

Collaborative social analysis

Of the 12 articles included in the review, nine were co-authored by two or more contributors, while three were single-authored works. This results in a collaboration index of 2.91, which can be considered moderate for an interdisciplinary field. Most articles are produced by small, ad hoc author groups, with little evidence of sustained collaboration across publications.

There are no clear clusters of recurring authors or institutional networks consistently leading research on AI-related teacher competencies. This finding reinforces the view that the field remains fragmented and exploratory. However, institutional actors such as UNESCO and Google for Education are beginning to emerge as anchors for future research.

Productivity by regions and academia

The geographical analysis indicates that the majority of the articles originate from Asia (5), North America (4), and Europe (3). This regional distribution is consistent with global trends in investment in artificial intelligence and educational innovation.

- In Asia, the focus is on alignment with national policies and pilot implementation initiatives, particularly in China and Singapore.
- In North America, the emphasis is more reflective, with ethical considerations and pedagogical exploration at the forefront.
- In Europe, interdisciplinary and equity-focused studies are gaining momentum, especially in Scandinavian countries and the United Kingdom.

Most contributions originate from universities and research institutes; however, intergovernmental organizations (e.g., UNESCO) and private sector actors (e.g., Google) also play a significant role. Although funding sources are not always explicitly disclosed, there is a growing trend toward hybrid partnerships that integrate academia, public policy, and industry.

Conclusions

This systematic review confirms the growing academic interest in developing artificial intelligence (AI) competencies among university teachers, particularly since the release of the UNESCO AI Competency Framework. The analysis of 12 peer-reviewed articles published between 2017 and 2025 shows that, while progress has been made in technical and pedagogical dimensions—such as AI foundations and AI-integrated lesson planning—other critical areas remain underexplored.

Notably, dimensions such as the human-centered mindset and AI for professional development receive comparatively limited attention, despite their central role in UNESCO's vision of ethical, inclusive, and learner-focused education in the age of AI. The data also reveal that research in this field remains fragmented, with limited author recurrence and weak institutional continuity. Most contributions appear as isolated efforts rather than as part of sustained academic programs or collaborative research networks.

Moreover, the predominance of publications in computer science journals, alongside the relative scarcity of articles in education-focused outlets, highlights the need for stronger engagement from faculties of education and teacher training institutions. Such involvement is essential to ensure a more balanced approach to AI in teaching—one that fully integrates pedagogical, ethical, and professional perspectives.

Looking ahead, future research should prioritize the holistic integration of AI across all five UNESCO competency dimensions. It should also foster collaborative networks, interdisciplinary approaches, and empirical studies that assess the real impact of AI on teaching practices and student learning outcomes. Expanding the geographic and linguistic diversity of publications will be equally important for building a more inclusive and globally relevant body of research.

Ultimately, equipping educators with the competencies required to navigate and shape AI-enhanced learning environments is not only a technological challenge, but also an ethical and pedagogical imperative.

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