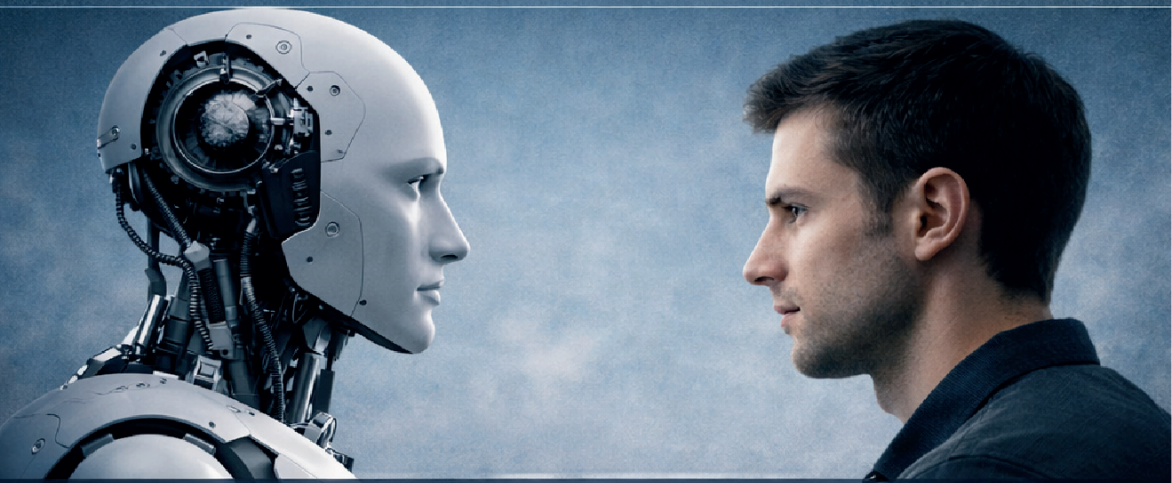
ARTIFICIAL INTELLIGENCE IN EDUCATION



EMERGING MODELS AND PEDAGOGICAL TRANSFORMATIONS

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www.bidgeyayinlari.com.tr - bidgeyayinlari@gmail.com
Krc Bilişim Ticaret ve Organizasyon Ltd. Şti.
Güzeltepe Mahallesi Abidin Daver Sokak Sefer Apartmanı No: 7/9 Çankaya / Ankara

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CHAPTER 1

FUTURE INSTRUCTIONAL MODELS IN EDUCATION

ÖZGÜ YALÇIN ÇER[1]

Hybrid Learning

Rapid developments in digital technologies, particularly the increase in artificial intelligence–supported educational tools, have led to the restructuring of teaching processes. The emergence of hybrid learning models has been one of the more significant results of the transformation. Hybrid learning consists of a method of delivering educational experiences that combines face-to-face instruction with online or distance learning, and does so in a systematic way that is also pedagogically coherent. The hybrid learning model allows for more than just learning in a traditional classroom; students have access to educational materials through digital means, and they participate in online learning and/or instructional activities at various times and locations. It has been found that hybrid models of learning have spread widely throughout higher education and lifelong learning. Recent studies find that hybrid learning can bring greater flexibility to education for students and ease the process of teaching (Wang et al., 2024). The primary

[1] Dr., Independent Researcher, Orcid: 0000-0002-1545-3358

objective of hybrid models of learning is to draw on the pedagogical advantages of face-to-face education while pursuing the flexibility of digital learning environments. In traditional settings, learning occurs mostly in class, which often fails to distinguish students' learning pace and preferences. The hybrid approach rearranges components of the learning process so children can learn not only from peers in the classroom, but also experience personalized learning in digital environments. Consequently, hybrid skills are important instructional strategies that promote student-centered instructional methods.

Recent research suggests that hybrid learning may enhance students' adaptability toward learning and make the learning design and delivery processes more engaging (Wang et al., 2024). The aim of hybrid learning models is to merge the prosocial effects of the face-to-face learning experience with the flexibility of digital learning environments. Learning in a traditional teaching environment depends to a large extent on in-class activities, but does not adequately take into account students' choice for learning. The hybrid learning model reorder different parts of the education experience into single integrated experience and provides a more sophisticated blended experience, student gain experiences to the class early but also have personalized experiences in digital learning environments. Learning analytics and hybrid learning. Hybrid learning methods are effective instructional methods that promote student-centred learning (Graham, Borup, Short, & Archambault, 2022). Learning analytics and AI-based systems characterize the interaction of students in online learning and provide perspectives on the process of learning. Learning processes can be redesigned for instructional methods by considering how engaged students are with content, students' progress through learning processes, and so on, along with their habits on task completion and performance criteria, enabling teachers to understand their students' learning processes

and provide personalised assistance when needed. AI-supported analytical systems can also identify likely areas for learning difficulty in advance of behaviour, and provide a recommended learning pathway for students (Zawacki-Richter et al., 2021).

Hybrid learning models offer great promise for improving education. Such models may allow students to become more actively engaged in learning activities in the classroom as well as the opportunity to more productively spend classroom time on discussion, problem-solving, and application, enhancing critical thinking and collaboration skills. Online learning environments allow students to pace their learning in accordance with their individual needs. This is a critical element of hybrid learning for students with varying learning rates. (Ifenthaler & Yau, 2020) Hybrid learning models require changes in teachers' roles. Traditionally, the teacher is perceived as a transmitter of knowledge; the role of a teacher in a hybrid learning environment shifts to being a planner and facilitator of learning activities. In hybrid environments, teachers are required to prepare course materials that transfer well to digital environments, design online learning tasks, and monitor students' learning processes. Therefore, the development of teachers' digital pedagogical competencies is a crucial requirement for the successful implementation of hybrid learning models (Graham et al., 2022). However, the hybrid learning model poses its own set of challenges. First, a robust technological infrastructure is needed for this model to come to fruition. Learning management systems, digital content creation tools, data analytics platforms and so on; a lot goes into enabling this model. Also, digital competencies need to be found in both teachers and students to take full advantage of digital learning environments. Inequities in technological access will also pose issues in hybrid learning environments (Boelens et al., 2020).

A key concern regarding the hybrid instructional design model is proper planning. Simply transitioning traditional teaching into an online format cannot be considered hybrid. It is important to re-evaluate the way that learning occurs from a pedagogical standpoint for hybrid learning to be successful. It is critical to distinguish what learning activities will be taught online vs. face-to-face. Additionally, assessing learning objectives, assessment methods, and providing feedback should occur in a manner consistent with hybrid instructional design (Ifenthaler & Yau, 2020). Hybrid instructional design will play an important role in the efficacy of educational organizations as they experience a digital transformation. Hybrid instructional design seeks to deliver better learning opportunities by marrying the interactive aspects of face-to-face learning with the flexible aspects of online learning. Through the use of artificial intelligence and learning analytics, hybrid learning can evolve into more personalized and intelligent environments. For hybrid instructional design to be successful, the education community needs to ensure that the hybrid instructional design model has been properly designed from a pedagogical perspective, that all teachers have the necessary digital pedagogical competencies, and that the technology infrastructure to support hybrid instructional design is adequate and appropriate.

Adaptive Learning Systems

Adaptive learning systems are platforms for delivering flexible educational content based on individual characteristics, learning speed, prior experience, and preferred modes of learning. These systems analyze the data and interactions created during the learning process to reconfigure instructional materials, activities, or feedback according to the particular needs of one or more students. The increasing popularity of digital learning environments has led to adaptive learning systems rapidly becoming a major area of interest in educational research as a technology-based approach to

implementing personalized learning strategies. Current research demonstrates adaptive learning systems' role in developing instructional design by taking individual variances into consideration, which aids in more effective management of the learning process (Khosravi et al., 2022). The foundational purpose of adaptive learning systems is to provide alternative pathways for learning that cater to an individual's needs; therefore, providing alternatives to the traditional "one-size-fits-all" methodology. Most educational institutions use delivery of materials in an identical manner for every student. However, students possess different cognitive structures, capabilities for learning, degrees of motivation, and levels of existing knowledge; consequently, universal methodologies of teaching will not sufficiently meet the educational needs of every learner. Adaptive learning systems facilitate individualization by utilizing student behavior data to monitor their reaction to educational processes (Drachsler & Greller, 2020). Consequently, utilization of adaptive educational processes leads to enhanced effectiveness and efficiency of educational processes.

Most adaptive learning systems consist of three basic components: a learner model, a domain model, and an adaptation mechanism. The learner model captures information on an individual's knowledge, learning preferences, performance data, and learning behaviour. The system updates this profile continuously by tracking all of the learner's interactions with the system. The domain model encompasses an understanding of the structure of the domain to be taught, the relationships between concepts, and the goals of the learning process. It helps the system figure out what sequence of content it needs to present. The adaptation mechanism is an algorithmic structure that uses data from the learner model to organize patterns of content, activities, and feedback. The three elements are integrated to produce a learning experience that is personalised for the student (Holmes, Bialik, & Fadel, 2022). One of

the key advantages of adaptive learning systems is the ability to provide ongoing feedback throughout the learning process. “These systems can evaluate students’ performance as they learn and identify strengths and weaknesses in real-time, enabling them to more easily see the problem areas where they need improvement and access more material in those areas. For teachers, the systems may provide them with a clearer understanding of students’ learning progress – actually to observe and track their learning, digest the data presented, and thereby modify their teaching.” (Khalil & Ebner, 2021).

Adaptive learning systems are highly intertwined with learning analytics and technologies for artificial intelligence. Learning analytics tools support producing a wide range of data with regard to students’ learning behaviors which can be analyzed via machine learning algorithms. In essence, as a result of these analyses, the system may foresee problems that a student will have experienced in learning and automatically recommend appropriate materials according to this criterion. This approach forms a basis for planning many of the data driven decision making protocols. They found that adaptive learning systems function best at increasing student engagement and improving student learning performance in online courses (Zawacki-Richter, Marín, Bond, & Gouverneur, 2021). One vast contribution of adaptive learning systems to the educational world is in increasing the student motivation to learn. As students are working with the learning materials at the appropriate individual learning pace, cognitive load is lowered and “the ‘noise’ in their heads becomes meaningful learning,” along with “personalized feedback increasing a student’s motivation to actively pursue their educational priorities,” that instills self-regulation in them. In the higher education and online learning contexts, research has revealed that the influences of adaptive learning systems on academic achievement and learning satisfaction is positive

(Ifenthaler & Yau, 2020). The challenges to implementation of adaptive learning systems follows. Following the development of such systems open the door for high levels of technical ability to be present as well as meaningful data infrastructure, secure online of students and the data they produce will have an evident effect on the use of such a system. This will directly affect the system's reliability as well as its sustainability in the educational context. In addition, if there are biases that exist in the dataset that algorithms are programming from, a negative effect or influence may come from this and be an obstacle for the system to overcome in order to provide accurate recommendations. These challenges do correlate to security of data sources and many of the algorithms, a good knowledge of ethical principle technologies will be important in developing adaptive learning systems. The educational institutions need to formulate some solid privacy policy practices to keep the student data protected, or develop professional training to help the teacher utilize the technology in the best light for the pedagogical priorities (Holmes et al., 2022).

In the future, adaptive learning systems are expected to be used more extensively in education. Advances in artificial intelligence and learning analytics will enable these technologies to develop more detailed learner profiles and further personalize learning processes. In particular, the progress of generative artificial intelligence technologies offers new opportunities for the automatic creation of learning materials and their adaptation to meet students' individual needs. However, for adaptive learning systems to be effectively implemented, pedagogical design must be aligned with technological infrastructure. In order for educational systems to keep pace with this transformation, it is essential to enhance teachers' digital pedagogical skills and strengthen the technological infrastructure of educational institutions (Khosravi et al., 2022). In conclusion, adaptive learning systems are among the key tools that

form the technological foundation of personalized learning in education. These systems help organize educational processes more efficiently by taking into account students' individual learning needs. As adaptive learning systems continue to evolve through learning analytics and artificial intelligence technologies, they make a significant contribution to the widespread adoption of data-driven and student-centered instructional models. Nevertheless, for these systems to be effectively integrated into educational processes, it is crucial to consider pedagogical design, data security, and ethical principles.

Virtual Learning Environments

Virtual learning environments are integrated environments in which the actual teaching and learning takes place online and in which students can interact online with content, teachers, other students and the assessment component. These environments are not merely technical platforms where course materials are thrown but constitute a pedagogically substantial environment which brings together learning management functions, communication, collaboration, feedback provision, monitoring and assessment. Current research indicate that in many contexts virtual learning environments are not going to be a temporary holding place in the evolution of higher education and lifelong learning but have become a permanent part of the instructional landscape. A recent bibliometric and systematic review of virtual instruction found that virtual learning environments occupy a prominent place in teaching and learning research because of their inherent flexibility, accessibility, scalability and potential for personalization. Conceptually, virtual learning environments in a narrow sense form part of online instruction through learning management systems. The term virtual learning environment refers, in a broader sense, to platforms for synchronous teaching, asynchronous content, virtual laboratories, collaborative learning, simulation models, and even more often, to

virtual realities for education. Therefore, a virtual learning environment cannot be defined as merely one type of technology but is best understood as a variety of learning architectures that provide different levels of interaction and further learning purposes. Although virtual instruction in higher education used to be primarily described as "distance education," research has confirmed that this definition is no longer relevant (as it has moved far beyond distance education) and includes new dimensions, such as sustainable digital education, flexible instruction, individualized or personal instruction, and data-driven reflections (Makda, 2025).

One of the main benefits associated with using Virtual Learning Environments is that they allow the student to partially separate the act of learning from both place and time. Therefore, learners can access all course content at times convenient for them and can watch any of the recorded lectures as many times as they like. In addition, learners can review any of the course materials whenever desired and are provided access to many different types of learning resources beyond those available in traditional face-to-face settings. The availability of resources would create a distinct benefit for students working full-time and/or students who are studying from different geographic locations, and/or students who have varied rates of learning. According to bibliometric analyses of Virtual Instruction, flexibility and accessibility have been identified as two key affordances of Virtual Learning Environments; therefore, Virtual Learning Environments have the potential to establish a more equitable form of access to knowledge. Furthermore, there are additional benefits associated with accessing Virtual Learning Environments since they can provide opportunities for students to engage actively in their learning processes and can create a thoughtful and articulate means of tracking and assessing learner progress. Virtual Learning Environments can facilitate student engagement with material in a variety of ways through the integrated

use of discussion boards, real-time communication, collaborative document editing, peer evaluation, online assessments/assignments, providing digital feedback on assignments, and the use of learning analytic dashboards.

The flexibility with regards to both time and location of learning is one of the most advantageous aspects of utilizing virtual learning environments. Students can often access all course content at their convenience and have the ability to view recorded lectures as often as they want. Furthermore, students can review course materials at will and have access to many types of learning resources not available to them through normal face-to-face classrooms. The availability of these materials will provide significant benefits for part-time students working full- time, part-time students who live in various areas around the world/students with unique learning styles/learning speeds. According to bibliographic analyses of virtual learning environments, flexibility and accessibility have been identified as two key advantages associated with virtual learning environments; therefore, virtual learning environments afford a more equal access to knowledge. ın addition, accessing virtual learning environments provides other benefits as well by providing learners with the opportunity to be actively engaged in their education as well as provide a comprehensive and organized way to monitor and assess a learner's progress. Many ways to support student engagement through the integrated use of various components of virtual learning environments, including discussion forums, synchronous communication, collaborative document creation/editing, peer review, online assessments, providing electronic feedback for assessments/assignments, and using analytics dash boards to measure the performance of students.

The interaction aspect of virtual learning environments is changed from the real-time social interactions one has with their peers and instructor to a variety of channels allowing for a different

type of interaction. The way students interact with each other and with the content of the course is primarily through the technology available to them. Richness within this new type of interaction between all three entities will not necessarily relate a student's level of surface participation with their level of deep learning. A student may post many times in the course forum, but this alone does not equate to a student experiencing quality learning. In addition, a student may have made themselves highly visible within their virtual environment, yet this will not necessarily result in higher levels of cognitive involvement. Therefore, current research states virtual learning environments must be evaluated, not simply by the frequency of use, but also by the quality of interaction and the relationship to learning outcomes. By integrating learning analytics into virtual learning environments, several types of data can be collected and utilized to enhance the instructional design of virtual learning environments and/or to identify students at risk for not succeeding early in their experience in the course and to provide students appropriate individualized support. A systematic review of the literature through research studies that examined the application of learning analytics in virtual and interactive environments demonstrates that the area of learning analytics research is rapidly evolving from a focus on learning outcomes and behavior analysis, to include performance prediction; self-regulated learning; social interaction; and emotional monitoring of students. Nonetheless, the new direction of the learning analytics research has produced additional prominent issues to address including: skill level in data interpretation, technical complexity, privacy issues, and issues related to scalability (Tao, Cukurova, & Song, 2025).

More advanced forms of virtual learning environments such as immersive virtual spaces and virtual reality-based learning platforms provide valuable opportunities to students that take courses requiring experiential learning. These environments can help

students visualize abstract concepts, safely simulate high-risk or costly experiments and create multisensory experiences that enhance student participation in active methods of learning. According to recent systematic reviews of virtual reality-based education, high levels of engagement and interaction in addition to the use of active learning approaches positively affect student outcomes. Additionally, while environment affects student outcomes, there is much variability in outcomes depending on the context and environments designed without the use of instructional principles may increase cognitive load. As stated by Oje, Hunsu, & Fiorella (2025), the effectiveness of pedagogical practices is based more on the quality of the design than on the technology itself. A unique aspect of virtual learning environments is that they can provide dual benefits related to both inclusivity and equity. On the one hand, virtual learning can provide students who have access-related barriers (e.g., geographic, temporal, or physical) with significant learning opportunities. Conversely, inequity can exist because of differences in access to devices, varying qualities of internet services, differences in levels of digital literacy, and differences in learning environments. Consequently, the efficacy of virtual educational technology is determined by variables such as the program's quality; the level of institutional support; the technological framework; and the type of guidance provided to students; all abiding by principles of universal design. Research regarding the efficacy of virtual learning within universities has recently revealed that issues related to digital inequity and access are significant topics in academia (Makda, 2025). Teachers are now viewed as strategically positioned within a virtual classroom as opposed to being the traditional providers of knowledge. They are now responsible for facilitating a student's learning within a virtual classroom; establishing and managing an interaction space; monitoring the level of engagement from their students; providing virtual feedback to students; and maintaining an active online

community of learners within their virtual class. The teacher's clear and equitable presence within a virtual classroom is critical when establishing motivation and a sense of community and belonging for students. The risks of separation, disconnection, or lack of participation for students increases in an environment that promotes ineffective communication between teachers, students, and peers (Caprara & Caprara, 2021). When creating an effective virtual educational environment, a combination of technical infrastructure, social connections, instructional support, and cognitions should exist.

In conclusion, hybrid learning, adaptive learning systems, and virtual learning environments collectively represent a paradigm shift toward more flexible, personalized, and data-informed education. While these approaches provide tremendous scope for increasing access, enthusiasm, and results, they succeed only when enabled by effective technological integration and sound pedagogical principles. Future directions for artificial intelligence, learning analytics and immersive technologies will further enhance the potential of digital learning environments, but we must ensure through ethical boundaries and best practice approaches that these systems will further, and not detract from, learning. Digital transformation success will not be defined by technology, but by the extent to which these designs meet learner’s needs. Prioritisation of pedagogy, equity and human centred design will unlock the potential of digital in education for more meaningful, inclusive and sustainable learning experiences.

Kaynakça

Boelens, R., De Wever, B., & Voet, M. (2017). Four key challenges to the design of blended learning: A systematic literature review. *Educational Research Review,* 22, 1–18. https://doi.org/10.1016/j.edurev.2017.06.001

Borup, J., Graham, C. R., West, R. E., Archambault, L., & Spring, K. J. (2020). Academic communities of engagement: An expansive lens for examining support structures in blended and online learning. *Educational Technology Research and Development, 68*(2), 807–832. https://doi.org/10.1007/s11423-020-09744-x

Caprara, L., & Caprara, C. (2022). Effects of virtual learning environments: A scoping review of literature. *Education and Information Technologies,* 27, 3683–3722. https://doi.org/10.1007/s10639-021-10768-w

Drachsler, H., & Greller, W. (2016). Privacy and analytics—It's a delicate issue: A checklist for trusted learning analytics. *In Proceedings of the Sixth International Conference on Learning Analytics & Knowledge* (pp. 89–98). ACM. https://doi.org/10.1145/2883851.2883893

Ifenthaler, D., & Yau, J. Y.-K. (2020). Utilising learning analytics to support study success in higher education: A systematic review. *Educational Technology Research and Development*, 68, 1961–1990. https://doi.org/10.1007/s11423-020-09788-z

Khosravi, H., Shum, S. B., Chen, G., Conati, C., Tsai, Y.-S., Kay, J., Knight, S., Martinez-Maldonado, R., Sadiq, S., & Gašević, D. (2022). Explainable artificial intelligence in education. *Computers and Education: Artificial Intelligence,* 3, 1-22. https://doi.org/10.1016/j.caeai.2022.100074

Leitner, P., Khalil, M., & Ebner, M. (2017). Learning analytics in higher education—A literature review. In A. Peña-Ayala (Ed.), *Learning analytics: Fundaments, applications, and trends* (pp. 1–23). Springer. https://doi.org/10.1007/978-3-319-52977-6_1

Makda, F. (2025). Digital education: Mapping the landscape of virtual teaching in higher education—A bibliometric review. *Education and Information Technologies*, 30, 2547–2575. https://doi.org/10.1007/s10639-024-12899-2

Oje, A. V., Hunsu, N. J., & Fiorella, L. (2025). A systematic review of evidence-based design and pedagogical principles in educational virtual reality environments. *Educational Research Review*, 47, 2-20. https://doi.org/10.1016/j.edurev.2025.100676

Tao, L., Cukurova, M., & Song, Y. (2025). Learning analytics in immersive virtual learning environments: A systematic literature review. *Smart Learning Environments*, *12*(43), 2-27. https://doi.org/10.1186/s40561-025-00381-6

Wang, S., Sun, Z., Wang, H., Yang, D., & Zhang, H. (2025). Enhancing student acceptance of artificial intelligence-driven hybrid learning in business education: Interaction between self-efficacy, playfulness, emotional engagement, and university support. *The International Journal of Management Education, 23(*2), 1-17. https://doi.org/10.1016/j.ijme.2025.101184

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—Where are the educators? International Journal of *Educational Technology*

in Higher Education, 16(39), 2-27. https://doi.org/10.1186/s41239-019-0171-0

CHAPTER 2

ARTIFICIAL INTELLIGENCE-SUPPORTED LEARNING ENVIRONMENTS AND NEW VISIONS IN EDUCATIONAL SCIENCES

ÖZGÜ YALÇIN ÇER[1]

Introduction

Educational sciences are currently undergoing one of their most profound transformations since the emergence of digital learning. Between 2020 and early 2026, artificial intelligence (AI) has evolved from a niche area within educational technology into a driving force shaping curriculum design, teaching and feedback practices, assessment systems, student support mechanisms, institutional policies, and scholarly debates on academic integrity. Recent reviews highlight that AI in education is no longer just intelligent tutoring or prediction models, but now spans generative AI, adaptive systems, learning analytics dashboards, automated assessment, and governance frameworks. Meanwhile, the field has become more self-critical, calling for stronger ethical frameworks, contextual sensitivity, and human oversight in response to the expanding scope of artificial intelligence technologies. In this way, the “new visions” emerging in educational sciences are not limited

[1] Dr., Independent Researcher, Orcid: 0000-0002-1545-3358

to technological innovation alone. When embedded and institutionalized, they lie at the heart of how learning is theorized, how teachers' roles might be reshaped, and how educational systems might define and redefine trust, agency, evidence, and fairness in data subjectivities (Hwang et al., 2020; Garzón et al., 2025). The most compelling contemporary literature suggests that AI does not act as a tool that educators, institutions, and stakeholders apply to existing educational systems. Rather, AI acts as a socio-technical layer in which learning and teaching now take place. "Although systems and tools for AI in higher education are proliferating, the approaches often lack rigor, ethical grounding, and interdisciplinarity" (Bond et al., 2024) and "while drawing on the rich conceptual landscape of ethics, the static principles of J.P. Gee's six principles of educational technology are insufficient for evaluating AI" (Nguyen et al., 2023). The field is entering a period in which technological innovation is co-constituted with pedagogical judgment and responsibility. The current question is not whether AI will enter education, but under what terms and to what ends (Holmes et al., 2022).

A key reason this transformation matters for educational sciences is that AI destabilizes several longstanding assumptions. Although curriculum, instruction, feedback, and assessment have traditionally been designed and implemented primarily by humans, with digital delivery systems playing only auxiliary roles, the emergence of AI-supported environments is shifting this paradigm to allow machines, without direct initiation by an educator, to recommend resources, to create personalized pathways, to generate content, to create draft feedback for instructors to edit, to create risk profiles that suggest when to intervene with a learner and to converse with learners. Nevertheless, many recent researchers assert that a more productive future lies in human–AI complementarity rather than machine substitution. Human-centered learning analytics and

AI studies suggest that opportunities should continue to be created for educational stakeholders to remain meaningfully involved in the design, implementation, and interpretation of ways to enhance but not supplant human decision-making using AI and related systems (Alfredo et al., 2024). One of the most influential recent developments in the field of education is to move away from standardization as a method of providing instruction toward adapting the learning experience for everyone in a responsive, adaptive, and personalized manner. The introduction of AI technologies as components of learning environments has expanded the notion of personalizing learner activity beyond an individual simply selecting an activity based on his or her learning ability. This includes the implementation of machine learning, multimodal data analysis, learner profiling, and generative support systems for dynamically adapting learner activity to individual characteristics. In addition, recent meta-analyses of empirical research studies have demonstrated how AI technologies have been integrated into adaptive learning environments to provide personalized instruction by matching instructional resources to learning profiles based on pacing patterns, performance data, and real-time feedback. For example, Hariyanto et al. (2025) describe adaptive learning environments as a data-driven system where different forms of learning can be combined with multimodal data analysis to continuously improve the quality of learning experiences. Merino-Campos (2025) similarly indicates that the use of AI as a means of personalizing learning opportunities for students in postsecondary education will enhance learner motivation/engagement, support adaptive learning, and assist in the streamlining of academic workflows provided the use of AI is pedagogically aligned with the objectives of the learning experience.

The shift represented by this new vision of learning and education is of critical importance because it signifies a movement

from traditional cognitive approaches within educational sciences towards an ecological paradigm of learning. In relation to this ecological paradigm, learners are no longer seen as passive recipients of information, but as evolving participants in learning who have their own needs, pace, misconceptions, and interaction patterns that can all be better understood using data. However, the most recent literature remains cautious about the risks of naive techno-optimism due to the wide prevalence of this new technology. According to Díaz and Nussbaum (2024), the use of AI in teaching and learning in schools should be based on what they call "pedagogical intelligence," which means that the educational utility of AI will depend on whether these systems are designed around meaningful learning rather than solely for efficiency or automation. In other words, if personalization is unaccompanied by pedagogy, then it will likely become procedural customization rather than transformational education. The emerging vision requires a greater connection between learning analytics and the design of AI within educational sciences and the development of learning theories that go beyond just computational methodology (Díaz & Nussbaum 2024). The introduction of generative artificial intelligence has expedited the transformation by providing tools that allow for the creation of large-scale explanations, examples, quizzes, simulations, and feedback, as well as support through dialogue. Recent reviews of this technology indicate it has redefined educational support because generative AI can be understood as a cognitive support, a writing assistant, a brainstorming partner, or an engine for simulation. The increase in the use of generative AI will also redefine how students learn because if generating knowledge becomes increasingly based on generating instructions to generate machine artifacts, the field of education will need to rethink its understanding of literacy and competence. Park's (2025) systematic literature review shows that students have a moderate understanding of generative AI; however, they have the most difficulty with creating

appropriate prompts, evaluating machine-generated artifacts and understanding privacy and academic integrity. Therefore, there is now a new learning agenda, and rather than just understanding how to use technology, learners must also develop competency as it relates to evaluating, prompting and curating machine-generated artifacts.

Thus, the teacher's role is not disappearing; it is becoming more sophisticated. Studies in K–12 and higher education consistently show that AI systems work better with teachers as pedagogical orchestrators. Alfarwan (2025) points out in her review of generative AI in K-12 education that while GenAI can support teaching and learning, "agency and decision-making with respect to curricula, use of technology, and monitoring students must stay with the teacher, as the AI systems 'behind the curtain' do not account for the child's lived realities and developmental needs in a local ecology, their background knowledge, or the local cultures, unless incorporated." AI systems that are not aligned with the complexity of classroom contexts risk failing to realize their full potential. The educational sciences are pushing toward a view of teaching as less about delivering fixed content and more about curating, moderating, interpreting, and ethically framing AI-mediated learning experiences (Alfarwan, 2025; Díaz & Nussbaum, 2024).

Another important area in which new visions are appearing is assessment. AI has opened up the range of things we can assess, how quickly we can assess them, and how feedback can be provided. Gao et al. (2024), in a systematic review of automatic assessment of text-based responses in post-secondary education, shows that AI and natural language processing are being increasingly adopted to assess open-ended responses and support feedback in higher education. This is attractive because text-based assessment tends to be slow and not easily scalable, particularly in large-enrollment situations. AI-supported assessment opens the possibility of faster formative

feedback, and richer feedback cycles, and more opportunities for writing than many traditional systems can support. Yet the literature makes clear that AI-based assessment is not automatically synonymous with educational quality. Assessment is not an act of mere classification; it is interpretive and laden with values. If AI systems optimize solely for classification efficiency, its meaning will be narrowed to its most pedagogically deficient sense- privileging performance over reasoning, creativity or moral judgment. This danger is especially acute in the generative AI era, because students can generate sophisticated outputs from GenAI that look authentic and can even pass peer review by experts themselves. Kofinas et al. (2025) present both quantitative and qualitative evidence that authentic assessments do not automatically protect academic integrity because generative AI produces an output that appears more likely than not to evade even experts' defenses. This study is sorely needed because it explicitly challenges what is perhaps the most common "rehabilitation" of AI simply to switch to "authentic," assessments to solve the generative AI problem. Our new vision of the educational sciences... "requires that we approach assessment as a socially situated, process-oriented, dialogic practice, rather than as an output or object in and of itself" (Kofinas et al., 2025).

AI-supported feedback and learning analytics are also extending teachers' and institutions' reach for understanding student progress. Cabral et al. (2025) show that while AI-enhanced learning analytics dashboards are used primarily for predicting academic performance, self-regulated learning support, and teacher-facing applications, the dashboards have weaknesses in real-world deployment and in causal evidence, in addition to privacy, bias, and explainability. This is a significant point for the educational sciences; in the datafied pedagogy of the future, the question will not only be whether predictions are correct, but whether they are pedagogically interpretable and associated with humane responses. A predictive

dashboard that flags risk but does not channel teachers into meaningful responses could increase surveillance without increasing learning (Cabral et al., 2025; Alfredo et al. 2024).Recent work provides perspective on the increasing governance dimension of AI-mediated education. McDonald et al. (2025) found that many U.S. higher education institutions appeared to be moving from an initial regulatory response to constructively guiding their classroom use of the technology. Jin et al. (2025) take this further onto the global stage, revealing both quite significant variation in institutional or adoption of policies across regions and also quite significant variation in the global policy landscape. These works reinforce points about the educational sciences being increasingly the same as institutional governance that curricula, assessments, staff development, and student support systems, and so on, all create the conditions for whether AI will end up pedagogically good, bad, or ugly. The 'next step' is not 'classroom innovation' but 'governed pedagogy' - design processes and the policymaking of institutional authorities must be understood in concert with profound implications for both (McDonald et al. 2025; Jin et al. 2025).

The most persuasive literature suggests an AI in education that is as much ethical and political as it is pedagogical. Ethical literature from around 2021 seems to crowdsource its issues: privacy, transparency, bias, accountability, inclusion, human agency, and data governance. Holmes et al. (2022) called for a community-level framework for ethical AI in education fairly early. Nguyen et al. (2023) provides more extensive ethical principle mapping for AIED, which continues to highlight earlier themes of justice, non-maleficence, and learner rights. Some of these same issues have been amplified with generative AI. García-López and Trujillo-Liñán (2025) state that GenAI in education can only be beneficial or useful when it subserves ethical, legal, and pedagogic fundamentals, and call for development of inclusive regulatory frameworks to play

catchup with “the greater democratisation of technology” through stronger digital literacy. A major trend for 2024-2026 will simply be a shift from ethic to structure critiqe. Adu & Owusu-Agyeman (2026) even use critical social theory to talk about the “dark side” of AI in education. Their review argues how AI can exacerbate educational inequality, intensify scarcity, redistribute power relations, affect cultural identity (especially educational systems imported into a not-equal environment), and call for greater democratic oversight. The literature is useful for being a warning shot across the bow of educational sciences around the peril of only approaching AI through a pure functional lens. The systems may all work, technically, and still reproduce exclusion, or epistemic injustice, or asymmetrical control of knowledge and decision making.

Equity is front and centre in any genuine new vision for the educational sciences. AI systems for educators-in-training do not exist in a social or moral vacuum. Language background, disciplinary culture, access to technology, access to disability support, prior familiarity with AI, all mediate who wins and who loses in any given AI system. Stöhr et al. (2024), looking at surveys of students across lots of Swedish universities, highlighted both the broad awareness of ChatGPT but huge differences across gender and field of study. Female students and students in the humanities and in medicine expressed far more concerns and far less positive attitudes than students in techy fields (those studying tech stuff, not teacher tech stuff necessarily). The differences are interesting, not least because they do not demonstrate that certain types of students are ‘behind’ but rather that adoption is mediated differently by identity as well as discipline and ‘riskiness’. Teacher trust is similarly complicated. Lyu et al. (2025) found that instructors might express moderate-to-high familiarity with concepts while not commonly reporting using AI directly in class. Their work is invaluable in that,

rather than taking ‘trust’ and ‘distrust’ as endpoints along the same pole of meaning they conceptualize the two instead not as opposites but as separate constructs. I think there are key implications for the educational sciences here - as always, innovation must be engaged with on the basis of some level of trust, but not blind adoption. In a wise and mature AI-supported education system, teachers know when to trust AI, when to interrogate it and when to ignore it entirely. This kind of professional discernment is not an ancillary educational competence, it is a core educational competence.

By 2025 and early 2026 literature began to arrive at a more synthetic view: AI is an affordance ‘to disrupt the educational sciences also in terms of who gets to do research, who gets to speak through institutions, and who has global epistemic power’ (Dai et al., 2026). In their bibliometric review of ‘GenAI in higher education’’ Dai et al. characterize ‘all of this’ as a very fast-growing area of research now full of ‘chatter’ about ‘academic integrity, ethics, and global asymmetries in knowledge production’ and we interpret this as an important sign that the field is deepening are getting more reflexive: the question is now not only ‘what should we do with this AI tool in education?’ but also ‘who gets to tell the hegemonic stories? who makes the policy? how is epistemic authority reshaped because generative systems now mediate all teaching/writing/assessment.’ In this sense, the educational sciences must be comparative, policy aware, and self-critical who does AI systems serve? Garzón et al. (2025), in reviewing and drawing lessons from the 155 empirical studies they cover, “develop their understanding that..the impact of AI in education usually has a promising upside but also persistent downsides that need to be discussed closer”, and “get to know that the design and implementation need careful educational analysis and interpretation.” Across the literature the strong scholarship no longer just praises AI for being ‘modern’, it demands, does it expand

sensemaking? does it augment genuine public participation? does it help defend educational good? This is the strongest new vision of all. Not displaced educational sciences by computational sciences, rather a reminder of ourselves to hold the technology to account in educational terms.

In the past few years we have gone from discussing applications of AI in education to discussing fundamental changes in the way we theorize and use education (i.e. pedagogy, assessment, governance, ethics, research) based on our understanding of and experience with AI. The most significant thing I have learned as it relates to education is that we should not romanticize or dismiss AI; rather, we should evaluate whether or not it helps us achieve our goals of human flourishing, pedagogical intelligence, institutional responsibility, and social justice. Personalized learning experiences, automated formative assessments, learning analytics, and generative systems can be used to assist with these objectives. However, until we evaluate these technologies by an educational standard rather than by a technological one, we will never know if they will help us achieve these goals (Bond et al., 2024; Díaz & Nussbaum, 2024; Garcia- Lopez & Trujillo-Liñán, 2025). Therefore, as a field, the future of educational sciences must focus on 5 key areas: 1) pedagogically relevant personalization; 2) explicit GenAI literacy; 3) redesigned assessment systems; 4) human-centered/explainable analytics; and 5) equity-based governance. The focus of our dialogue and resulting actions should be on what kind of educational future we want to have, how AI will contribute to that educational future, and how we can hold ourselves accountable for human learning, the professionalization of teachers, and democracy. The future of educational sciences should not be about expanding our use of AI but instead creating a more meaningful, humane, and sensitive understanding of AI in education.

The breakneck populization of AI in the learning environment from 2020-2026 has upended the education sciences epistomelogically as well as pedagogically and institutionally. As we have considered throughout this book, the AI supported learning environment is not simply a sort of technology; it is a profoundly different infrastructure through which knowledge is produced, validated, spread and assessed. What it means to 'do education'' will depend much on how the education sciences make sense of AI as a socio-technical phenomenon. One of the most impactful consequences of this reinvention of classroom is that it unfixes our sense of both "knowing" and "learning." Whatever a student knows, in some ways it has come to them through teaching and practice and evaluation. In an AI inflected classroom, so much knowledge is produced or suggested or mediated by an AI inflected world in the learning environment. Learning and teaching will then need a new language for what we can begin to see as "augmented cognition," a sort of thinking in which other bits of intelligence (machine generated output) are both to be extended and to be outrun. The learning sciences will need to rethink the lexicon of understanding, originality, authorship, and authority. The collapsing boundary between student and machine product means student learning cannot be described in the lexicon of task, but of critical evaluation, epistemic judgement, and reflective use of AI (Kofinas et al., 2025; Park, 2025).

An alternate aspect of concern now refers to the shifting roles for both teachers and the work they do. To date, research supports that AI is not replacing teachers but is allowing teachers to become increasingly sophisticated pedagogical mediators. By informing their design of learning experiences and use of evidence (e.g., empirical evidence, descriptive statistics and normative data) and including an ethical dimension to AI-generated findings, teachers' work becomes more diverse in scope. However, does more diversity

in teachers' work mean that this work is superior to the ways AI can help teachers to do routine and repetitive tasks? Literature suggests that, when teachers are making more sophisticated judgments, they frequently look to empirical data for their support and may become overly dependent on AI. In this context, the research results from this study provide an opportunity to explore different modalities of integrating trust and scepticism into AI systems; this is not a limitation but rather a mechanism for generating innovation in education. Therefore, educators must acquire an analytical intuition that is pedagogically and ethically appropriate about the nature of both the educator and learner from what can be empirically determined. At the same time, there is an increasing prevalence of data analytic processes related to AI in education which provide considerable opportunities and hubris regarding the means by which data can drive educational decision making. While there are potentially immense benefits with the use of predictive modelling and dashboards to invest in learner engagement, achievement performance and risk, there will also be various interpretations of the data, responsibility, and corrective measure associated with the collection and use of the data. To simply predict student success will generally not afford significant value to the education process. If learning analytic as a whole are designed carelessly, a significant risk exists for educators to adopt a deficit model of education that can result in the objectification of the student or learner. Scholars suggest that a human-centred contextualised data model should be adopted by educators whereby both the learner and educator are able to interpret the contextualised data (Cabral et al., 2025; Alfredo et al., 2024). Thus, the field of educational sciences requires educators to develop an analytical intuition that is pedagogically and ethically appropriate for understanding both educator and learner.

The intersection of equity and inclusion provides yet another dimension relative to the current paradigm. Models of AI-based

educational technologies use vast amounts of data that contain intrinsic social, cultural, and linguistic biases. By applying these same models in a classroom setting, disadvantages will continue to exist or be further magnified for students who are members of underrepresented populations. Furthermore, due to inequitable access to technology and/or an inequitable level of knowledge and ability to appropriately use technology, these same students could be exposed to inaccurate or poorly represented information via their educational technology. Actions such as these could create a separate system of educational stratification based upon class structure. According to Adu & Owusu-Agyeman (2026), "The dark side of AI" creates local and global disparities through the additional transfer of authority from educators back to their students as well as sustaining hegemonic knowledge creation. Therefore, when considering how the education sciences could potentially implement AI in their field, a fundamentally critical and inclusive examination should be utilized. The ethical use of AI within/or education is changing from an abstract construct that only some educators think about to a tangible issue that will require action now. The early conversations regarding AI in education focused primarily on principles of accountability and transparency; however, more recent discussions have begun to center more around the need for operational guidelines to assist in making decisions that educators and practitioners will need to make. Institutions are responsible for establishing policy regarding the use of AI, consent to use AI, and the way in which institutions will evaluate and assess AI within their classrooms as well as for determining when and how institutions should evaluate and assess that use. There is an ethical and moral obligation to all parties involved in the use of any type of educational technology—whether they are developers, educators, institutional representatives, policymakers, or students—to share the responsibility of holding those parties accountable for using that technology ethically. Currently, more and more institutions are developing ethical

guidelines and/or governing frameworks regarding the use of AI in their classrooms; therefore, the use of AI must be approached through informed, deliberate action and collaboration by all parties involved in the creation and implementation of AI.

In conclusion, the integration of artificial intelligence into educational environments represents both an opportunity and a challenge for educational sciences. Technology has the potential to enhance personalization, improve feedback and assessment, and increase access; but it also raises difficult questions about knowledge, equity and ethics, and governance. The new horizon described in the literature is one of thoughtful optimism: AI could support better, more equitable education, so long as it is built within strong pedagogical and ethical guardrails, and a commitment to humane aims. The educational sciences need to lead to ensure that technological innovation is aligned with the ends of education: helping to create informed, critical humans who are citizens of a more complex world.

Kaynakça

Alfarwan, A. A. (2025). Generative AI use in K-12 education: A systematic review. *Frontiers in Education, 10*, 1-12. https://doi.org/10.3389/feduc.2025.1647573

Alfredo, R., Echeverria, V., Jin, Y., Yan, L., Swiecki, Z., Gašević, D., & Martinez-Maldonado, R. (2024). Human-centred learning analytics and AI in education: A systematic literature review. *Computers and Education: Artificial Intelligence, 6*, 1-23. https://doi.org/10.1016/j.caeai.2024.100215

Adu, K. K., & Owusu-Agyeman, Y. (2026). A systematic review of the dark side of AI in education: A critical social theory perspective. *Frontiers of Digital Education, 3*(2), 1-12. https://doi.org/10.1007/s44366-026-0084-0

Bond, M., Khosravi, H., De Laat, M., Bergdahl, N., Negrea, V., Oxley, E., Pham, P., Chong, S. W., & Siemens, G. (2024). A meta systematic review of artificial intelligence in higher education: A call for increased ethics, collaboration, and rigour. *International Journal of Educational Technology in Higher Education, 21*(4), 2-41. https://doi.org/10.1186/s41239-023-00436-z

Cabral, L., Pinto, R., & Gonçalves, G. (2025). AI-powered learning analytics dashboards: A systematic review of applications, techniques, and research gaps. *Discover Education, 4*(525), 2-27. https://doi.org/10.1007/s44217-025-00964-y

Dai, K., Liu, Y., & Zhang, X. (2026). Generative AI in higher education: A bibliometric review of emerging trends, power dynamics, and global research landscapes. *Computers and Education: Artificial Intelligence, 9*, 1-12. https://doi.org/10.1016/j.caeai.2026.100544

Díaz, B., & Nussbaum, M. (2024). Artificial intelligence for teaching and learning in schools: The need for pedagogical intelligence. *Computers & Education, 217*, 1-19. https://doi.org/10.1016/j.compedu.2024.105071

Gao, R., Merzdorf, H. E., Anwar, S., Hipwell, M. C., & Srinivasa, A. R. (2024). Automatic assessment of text-based responses in post-secondary education: A systematic review. *Computers and Education: Artificial Intelligence, 6*, 1-15. https://doi.org/10.1016/j.caeai.2024.100206

García-López, I. M., & Trujillo-Liñán, L. T. (2025). Ethical and regulatory challenges of generative AI in education: A systematic review. *Frontiers in Education, 10*, 1-15. https://doi.org/10.3389/feduc.2025.1565938

Garzón, J., Patiño, E., & Marulanda, C. (2025). Systematic review of artificial intelligence in education: Trends, benefits, and challenges. *Multimodal Technologies and Interaction, 9*(84), 2-19. https://doi.org/10.3390/mti9080084

Hariyanto, Kristianingsih, F. X. D., & Maharani, R. (2025). Artificial intelligence in adaptive education: A systematic review of techniques for personalized learning. *Discover Education, 4*(458), 2-18. https://doi.org/10.1007/s44217-025-00908-6

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Buckingham Shum, S., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2022). Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education, 32*, 504–526. https://doi.org/10.1007/s40593-021-00239-1

Hwang, G.-J., Xie, H., Wah, B. W., & Gašević, D. (2020). Vision, challenges, roles and research issues of artificial intelligence

in education. *Computers and Education: Artificial Intelligence, 1*, 1-5. https://doi.org/10.1016/j.caeai.2020.100001

Jin, Y., Yan, L., Echeverria, V., Gašević, D., & Martinez-Maldonado, R. (2025). Generative AI in higher education: A global perspective of institutional adoption policies and guidelines. *Computers and Education: Artificial Intelligence, 8*, 1-12. https://doi.org/10.1016/j.caeai.2024.100348

Kofinas, A. K., Tsay, C.-H., & Pike, D. (2025). The impact of generative AI on academic integrity of authentic assessments within a higher education context. *British Journal of Educational Technology, 56*, 2522–2549. https://doi.org/10.1111/bjet.13585

Lyu, W., Zhang, S., Chung Rachel, T., Sun, Y., & Zhang, Y. (2025). Understanding the practices, perceptions, and (dis)trust of generative AI among instructors: A mixed-methods study in the U.S. higher education. *Computers and Education: Artificial Intelligence, 8*, 1-18. https://doi.org/10.1016/j.caeai.2025.100383

McDonald, N., Johri, A., Ali, A., & Hingle Collier, A. (2025). Generative artificial intelligence in higher education: Evidence from an analysis of institutional policies and guidelines. *Computers in Human Behavior Reports, 17*, 1-11. https://doi.org/10.1016/j.chbah.2025.100121

Merino-Campos, C. (2025). The impact of artificial intelligence on personalized learning in higher education: A systematic review. *Trends in Higher Education, 4*(17), 2-15. https://doi.org/10.3390/higheredu4020017

Nguyen, A., Ngo, H. N., Hong, Y., Dang, B., & Nguyen, B. P. T. (2023). Ethical principles for artificial intelligence in

education. *Education and Information Technologies, 28*(4), 4221–4241. https://doi.org/10.1007/s10639-022-11316-w

Park, J. (2025). A systematic literature review of generative artificial intelligence literacy in schools. *Computers and Education: Artificial Intelligence, 8*, 1-22. https://doi.org/10.1016/j.caeai.2025.100487

Stöhr, C., Ou, A. W., & Malmström, H. (2024). Perceptions and usage of AI chatbots among students in higher education across genders, academic levels and fields of study. *Computers and Education: Artificial Intelligence, 7*, 1-12. https://doi.org/10.1016/j.caeai.2024.100259

CHAPTER 3

TEACHERS' ATTITUDES, TRUST, AND PEDAGOGICAL ADAPTATION TOWARD ARTIFICIAL INTELLIGENCE IN EDUCATION

ÖZGÜ YALÇIN ÇER[1]

Introduction

Artificial intelligence (AI) has rapidly emerged as a transformative technology in education, reshaping teaching, learning, and assessment practices across diverse educational contexts. Since 2020, the acceleration of digital transformation in education, partly driven by global disruptions such as the COVID-19 pandemic, has significantly increased the adoption of AI-powered tools in learning environments, including intelligent tutoring systems, automated assessment platforms, learning analytics, and more recently, generative AI tools capable of producing human-like text and feedback (Zawacki-Richter, Marin, Bond, & Gouverneur, 2019; Kasneci et al., 2023). The growing presence of AI in education is both a technological and pedagogical phenomenon. AI systems enable personalized learning experiences by adapting content, pacing, and feedback to individual learner needs, supporting a more differentiated form of teaching and learning (Holmes, Bialik, &

[1] Dr., Independent Researcher, Orcid: 0000-0002-1545-3358

Fadel, 2022). This development aligns with contemporary educational paradigms that espouse learner-centered learning and the need to develop 21st-century skills such as critical thinking, problem-solving and digital literacy at scale (Redecker, 2021). AI has the potential to reduce teachers' administrative workload, allowing them to focus on higher-order instructional practices (Luckin, Holmes, Griffiths, & Forcier, 2016). However, the integration of AI into education also raises significant ethical, trust-related, and equity concerns that emerge from the use of AI in education including, but not limited to algorithmic bias, data privacy, transparency, and reliability of AI-derived products which have become central topics in recent educational research (Williamson & Eynon, 2020; Holmes et al., 2022). These concerns are particularly salient in classroom contexts, where teachers must make informed decisions about adopting and using AI technologies (Lee, Arnold, Srivastava, Plastow, Strelan, Ploeckl, Lekkas, & Palmer, 2024). Teachers' perceptions of AI technologies are critical not only because they are users of these tools, but also because they act as mediators between technology and students, shaping how AI is integrated into learning processes.

Conceptualizing Artificial Intelligence in Education

Artificial intelligence in education can refer to the application of computer systems to perform tasks that typically require human intelligence, such as recognizing patterns, making predictions, classifying information, understanding language, providing feedback and instructional support, and making adaptive teaching and learning decisions. In more recent literature, AI in education is not considered a narrow technical add-on, but a much broader socio-technical field encompassing work in machine learning, natural language processing, learning analytics, intelligent tutoring, automated assessment and evaluation, and human–computer interaction. Recent review studies demonstrate that the field has

grown significantly in scale and scope over a relatively short period from more narrow and specialized usages towards more complex ecologies of instructional, evaluative and assistive tools (Williamson & Eynon, 2020; Crompton & Burke, 2023; Wang, Wang, Zhu, Wang, Tran, & Du, 2024). Between 2020 and 2022, there was still a tendency to prioritize automation-oriented systems optimized for efficiency, accuracy, and scalability. Research was focused on predictive analytics, automated scoring, early-warning systems, recommendation engines, and intelligent tutoring systems based on structured inputs and predefined tasks. In other words, AI was primarily conceptualized as supporting decision-making through data-driven analysis and algorithmic processes rather than as a partner in meaning-making or knowledge production (Williamson & Eynon, 2020). This reflects the logic of instructional automation, AI can detect at-risk students, score objective responses, recommend learning content and provide pre-programmed feedback where the rules of the task are relatively fixed.

Also, the analytical development of the field was reflected in the emergence of comprehensive review studies over the course of both 2023 and 2024 that identified a large body of literature pertaining to artificial intelligence in educational settings, along with multiple clusters related to areas such as applications, theoretical frameworks and methodological approaches. Wang et al. (2024) identify patterns of use such as transformative applications for adaptive learning and personalized tutoring, intelligent assessment and management, profiling and prediction, and other emerging AI products. Crompton and Burke (2023) show that as higher education research progresses, applications of AI are categorized into themes such as evaluation, prediction, AI assistants, intelligent tutoring systems, and learning management for students. This diversification is significant, indicating that AI in education is not a single, but a family of technologies for different pedagogical and administrative

purposes. (Wang et al., 2024). Generative AI has represented a critical inflection point since late 2022 particularly brought about by ChatGPT and its siblings and generative AI have led to a substantial increase in academic interest and use with sharp increases in publication and an expansion of conceptual vocabulary. AI systems have transformed the lexicon from systems that classify, predict, and recommend to systems that explain, question, summarize, generate lesson plans, and write code and converse with users in natural language. Generative systems represent a major paradigm shift in how we think about human labour and the products of that labour, both in terms of representation and application. As recent reviews remark, the post-2022 period represents a structural shift in AI from background infrastructure and towards the foreground as an interface for teaching and learning (Kasneci et al., 2023, Memarian & Doleck, 2023). For this reason, over time our understanding of AI in education increasingly emphasizes hybridity rather than replacement. In more recent conceptualizations of AI in education, AI is framed as part of a human-centered ecology of educators, students, algorithms, interfaces, and institutional norms. A call for greater attention to ethics, trust, human agency, and pedagogical alignment in AI in education work has undeniably shaped this trajectory. Bond, Khosravi, De Laat, Bergdahl, Negrea, Oxley, Pham, Chong, & Siemens (2024) suggest that the second phase of AI in higher education entails more ethics, collaboration, and methodological rigor, while Alfredo, Echeverria, Jin, Yan, Swiecki, Gašević, & Martinez-Maldonado (2024) show how the exclusion of some stakeholders in the development of AI-enhanced learning analytics systems results in mistrust and misalignment between that system and its users. Thus, through the period from 2020 to 2026, the central conceptual arc of AI in education is one that moves from efficiency-driven automated forms of educational intelligence toward more dialogic, generative, and human-centered forms.

Applications for Artificial Intelligence in Teaching and Learning

The educational uses of AI can be categorized into several overlapping domains. The first is personalization, or adaptive instruction. AI-driven systems analyze student performance, patterns of responses, and behavioral data to adjust elements such as difficulty, order of presentation, prompts, and feedback, especially clear for intelligent tutoring systems and other computer-aided environments. Review studies continue to demonstrate that these systems can help with learning gains, particularly in constrained subject matter domains in which the system can model learner progress and provide hints at the right moment. A 2025 systematic review of AI-driven intelligent tutoring systems in K–12 reveals generally positive effects on learning and performance, while also cautioning that positive effects are contingent on research design, length, and comparison conditions (Wang et al., 2024; Létourneau, Deslandes Martineau, Charland, Karran, Boasen, & Léger, 2025). A second significant area of AI application is assessment and feedback. AI is used to score responses, identify patterns in learner performance, generate formative feedback, and enable assessment for learning. Reviews in this area indicate that assessment is one of the most frequently studied of AI uses in educational contexts. The literature also makes clear that pedagogical value depends on more than speed and automation; quality, interpretability, and fairness of AI-generated judgments represent key considerations. In this sense, AI-assisted assessment is pedagogically useful when it supports decision-making about learning first, not merely valuing speed of evaluation (Crompton & Burke, 2023; Memarian & Doleck, 2023; Luo, Zheng, Yin, & Teo, 2025). A third key domain is the domain of applications of learning analytics and educational decision support. Here AI detects patterns of engagement, predicts risk of dropout, classifies learning behaviors and identify students for instructor

dashboards or recommendations. These tools promise to flag educators at risk soon enough and allow for more effective instructional planning, yet they raise difficult questions of student surveillance, agency, and the meaningfulness of data-based behaviors. Human-centered reviews argue that analytics-driven AI should not reduce students to risk profiles or render them invisible as data points. Meaningful human-centered implementation of these systems requires teacher involvement, learner participation, and clear attention to trustworthiness, transparency and educational purpose (Bond et al., 2024; Alfredo et al., 2024). A fourth and perhaps growing use is that of teacher support. Early experiments and products are now available to help teachers with lesson plans, drafting materials, making rubrics, quizzes, lesson summaries, and differentiated explanations. This application gained prominence with the emergence of generative AI, and current reflections from the teacher perspective suggest educators see considerable potential for content preparation, productivity, and instructional AI, but also uncertainty around accuracy and responsible use, and professional development needs. A 2025 systematic review on AI in teaching and teacher professional development finds that most studies focus on AI in teaching itself, and less on AI being used to support teachers' own learning and professional development. This question of teacher competence, self-efficacy, and judgment is very relevant to book chapters on teachers because teaching and learning effectively in the classroom will depend less on the technology than on teacher competence in using it (Tan, Hu, Yeo, & Cheong, 2025).

From Automation to Generative Systems

The most important conceptual change over the past few years is the shift from automation-centered to generative AI. Automation-centered tools are relatively task-specific: they classify, score, recommend or predict existing data structures and explicit goals. They have pedagogical value to the extent that they are

consistent, scalable, and time efficient. Generative systems, in contrast, generate new text, explanations, examples, simulations, dialogue and more in response to prompts. This change transforms AI's role in education from a background evaluator to an expert interlocutor in communicative and epistemic processes. Teachers and learners, who were previously consumers of machine output, are now co-constructors of prompts, interpretations, revisions, and critiques (Kasneci et al., 2023; Memarian & Doleck, 2023). Generative AI expands what AI can do in classrooms and higher education. It can draft examples; simulate dialogue; scaffold brainstorming; translate complex content into simplified language; create formative questions; support writing; and provide immediate conversational responses. Experimental synthesis suggests that these tools can improve academic performance, motivational outcomes, and higher-order thinking in some circumstances, and particularly when they are used to engage students through authentic classroom tasks rather than just isolated novelty tools. At the same time, the evidence also cautions against overly optimistic assumptions. The benefits of generative AI are mediated by task design, learner expertise, subject matter, and the quality of human oversight (Deng, Jiang, Yu, Lu, & Liu, 2025; Lee et al., 2024).

Yet generative AI also amplifies existing educational risks. Research points to concerns related to hallucinated content, bias, privacy, opacity, overreliance, and academic integrity. What is new about the generative phase is not that these risks are necessarily new, but that they arrive in more immediate and pedagogically impactful forms. If a predictive system incorrectly identifies a student as at risk, the harm is necessarily at least somewhat hidden. If a generative system creates misleading explanations, fabrication references, or polished shallow responses, the pedagogical harm is more directly embedded in learning activity. Hence current scholarship increasingly argues that generative AI ought to be understood

through human-centered, ethically grounded, and pedagogically explicit rather than technological frameworks (Williamson & Eynon, 2020; Bond et al., 2024; Alfredo et al., 2024). Put together, the shift from automation to generative systems signals not only a shift in technical architecture, but a shift in conceptualization of AI in education. Earlier AI systems were about optimizing over educational processes, generative AI is increasingly intervening in the learning process itself by shaping discourse, representation, and knowledge production. Understanding AI in education therefore involves both continuity and transformation: it is continuous in that personalization, assessment, prediction, and tutoring remain central; and transformative in that generative systems position AI within dialogic, creative, and epistemic processes that challenge traditional assumptions about authorship, expertise, and pedagogy. This is why any analysis of teachers' attitudes and trust, and adaptation pedagogically today must recognize that AI in education is both an infrastructure of automation as well as what can be described as a generative interface.

Theoretical Framework

Understanding teachers' attitudes, trust, and pedagogical adaptation toward AI requires us to draw on multiple theoretical understandings. The issue of integrating AI into teachers' instruction cannot simply be assumed as a 'technology' issue but needs to be rooted in socio-cognitive and pedagogical understanding that can be traced through teachers' beliefs, perceptions, contextual and institutional conditions, as well as through their professional practices. As a result, this chapter relies on four complementary theoretical perspectives: the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), trust theory in educational technology, and pedagogical adaptation models.

The technology acceptance model (TAM), introduced by Davis in 1989 was intended to explain users' acceptance behavior, and the two main factors that determine users' attitudes towards technology. Perceived usefulness of the technology and perceived easiness of use, and both factors influence users' behavioral intention and actual use. TAM has been utilized in multiple situations for examining teacher intention to adopt innovations, such as intelligent tutoring systems, learning analytics systems, and generative AI tools. (Scherer, Siddiq, & Tondeur, 2021). More recent studies have extended TAM by adding variables such as digital competence, self-efficacy, perceived risk, and ethical perceptions. These studies show, for example, that teachers perceive AI tools as useful because they automate repetition, assist with administration, and provide engagement as a gamification tool for teaching. However, concern about their unreliability/accuracy as a source of information, ineffective size bias, and loss of professional control negatively affects their attitude towards using these tools. Furthermore, in an age of generative AI, enhanced usefulness may no longer be purely tangible efficiency gains but also an improvement of cognitive and instructional creativity. For instance, a teacher may evaluate a generative AI tool based on its ability to explain something, give them material to work with, or drive an interactive learning experience. With this, TAM may need to be read in a broader sense of what 'usefulness' can entail.

The unified theory of acceptance and use of technology (UTAUT) captures the essence of earlier acceptance models, including the TAM model, into one unified model using multiple theoretical perspectives. Four determinants of technology adoption were identified: performance expectancy; effort expectancy; social influence; and facilitating conditions. These factors account for users' behavioral intention and actual use of technology (Venkatesh, Morris, Davis, & Davis, 2003). UTAUT is commonly used within

education when exploring the effects of social/contextual variables as they relate to teacher adoption of artificial intelligence (AI) technologies. Performance expectancy corresponds to the belief of teachers, whether or not their belief supports that AI would help increase their effectiveness. Effort expectancy is the extent to which teachers perceive that AI would be easy to incorporate into their existing practice. Social influence relates to our colleagues and school leaders, as well as policy influences. Facilitating conditions are the available resources to help teachers utilize technologies like AI (Scherer et al., 2021). A body of recent research suggests UTAUT has a greater explanatory power and account of variance in the adoption of AI technologies compared to TAM and is more appropriate than those explanatory variables in a complex educational ecosystem. Even if teachers believe AI is a beneficial technology, a shortage of institutional support or the absence of professional development opportunities can limit the implementation of such technologies (Chiu, 2024). Furthermore, with generative AI emerging, the significance of the aforementioned social influence is likely to be amplified as many teachers rely on their professional network and peer communities to explore this new concept of technology.

Acceptance-type models such as UTAUT and TAM are useful for understanding whether or not teachers will be willing to engage with existing AI systems, however, none are adequate to address the core issue of trust, which is increasingly central in today's world that includes intelligent and generative systems. Teachers' trust in AI within an education context will typically hinge upon the perceived accuracy, consistency, as well as fairness and transparency of the outputs produced by those systems. Teachers need to believe that the AI performing according to their given specification will create results that are valid, unbiased, and pedagogically appropriate for use within their practice (Holmes et al., 2022). Akgun &

Greenhow (2022) argue that bias and error can result in serious consequences when used for high-stakes assessment and feedback purposes. The use of generative AI systems complicates the issue of trust; traditional systems generally were limited to making binary decisions as to whether a given operation was successful or unsuccessful, while generative systems create actions based on probability leading to the generation of outputs or information that is susceptible to misinformation and ambiguity (Kasneci et al., 2023). As such, trust becomes an ever-evolving and contextually fluid resource that is built by interacting with a system instead of being assumed as an inherent characteristic of the technology. Newly published studies focus on the similarity of trust in AI to that of trust in all technology and generally outline that teachers' professional judgment and agency tend to drive how much they trust AI-augmented systems. Trust is more likely when teachers can evaluate systems critically, understand their application's operation, and maintain control over the decision-making processes in their instructional practices.

Pedagogical Adaptation Frameworks

The incorporation of AI into education will necessitate not only the willingness to accept as well as trust and also the degree to which teaching methods, educator’s roles in education, and classroom practices can be modified to accommodate these new technologies; as such, frameworks of pedagogical adaptation to understand how class teachers adapt their methods of delivery and instructional practice when confronted with new technological advancements; therefore models representing this adaptation suggest that the incorporation of technology into educational activities is a multidirectional activity with respect both to teacher’s belief systems and to a reformulation of teachers’ knowledge base and identity as an educator (Redecker, 2021). The Technological-Pedagogical Content Knowledge (TPACK) framework is one model that

describes the integration of a teacher's technological knowledge with pedagogical and subject content knowledge to be able to effectively assist their students in achieving their learning goals. According to Redecker (2021) in regards to this framework teachers who engage in using AI-supported pedagogy and learning will be using AI to assist their students achieving their learning goals in subjects and general pedagogical content knowledge that they are competent in assisting their students achieve; therefore AI-supported educators will also be supporting students in achieving their individual learning goals at each of the various levels of interaction.

Another important area of focus is the transformation of the role of the teacher, wherein AI-enabled environments reposition teachers as facilitators, designers and mediators of learning, rather than providers of knowledge. This points to a real challenge in terms of classroom dynamics, assessment and engagement (Luckin et al., 2016). For example, the use of generative AI gives rise to opportunities for inquiry-based learning, or for collaborative tasks or personalised feedback that increases student autonomy and participation. However, adapting to a pedagogy can be difficult; teachers may not know how to go about it or may feel they do not have the support or time to change things. Education can struggle to keep up with the rate of technological development, leading to hesitance and the retention of outdated teaching practices. Recent studies have suggested that successful adaptation is made easier by school support and reflective practice, and that this is tied to ongoing professional development opportunities (Chiu, 2024).

Teachers' Attitudes toward Artificial Intelligence

Teachers' attitudes to AI in school are critical to how these technologies are perceived and used in classrooms. Attitudes can be conceived of not simply as dispositions, but as psychological constructs formed through cognitive appraisal that lead to affective response and can subsequently be reflected in intention to act and

actual behavior in the case of AI adoption, how teachers use AI tools and services, and how critically they use the outputs of AI (Scherer et al., 2021; Chiu, 2024). Teachers' attitudes to AI are also dynamic, in part because the technology of AI is still developing, including the emergence of generative systems. Compared with older forms of educational technology, AI offers greater uncertainty, autonomy and epistemic richness, and so seems to inspire ambivalence in teachers, feathers for eagerness for innovation tempered with fears for reliability, ethics, and professional identity (Kasneci et al., 2023). Understanding attitudes may require a multifactorial conception of its cognitive, affective, and behavioral components.

Educators' views toward AI consist of their cognitive views, which include their cognitive basis or beliefs and what they know about what AI can be used for. Educators typically evaluate the utility, efficacy, efficiency or pedagogical value of AI through a lens of their own perceptions of the utility of AI for individualized learning or relieving administrative burdens on them (Chiu, 2024; Scherer et al., 2021). Concerns regarding algorithmic bias, opacity, and error often lead to skepticism or hesitancy regarding AI use (Holmes et al., 2022). It is hard to gauge the emotional response of educators toward AI (the affective domain) since responses can vary widely among educators (e.g., excitement, curiosity, anxiety or fear). The introduction of generative AI has intensified emotional responses of educators. Generative AI demonstrates how generative AI challenges traditional views of who is an expert, who is an author and what it means to hold power, while simultaneously generating positive emotional responses such as enthusiasm and motivation to create and teach with generative AI (Kasneci et al., 2023). Emotional responses of educators are critical because they can enhance or deter from using AI based on how educators perceive AI's usefulness. Finally, there is a behavioral component regarding educator intention to utilize or use AI tools or systems. How educators choose to utilize

AI systems or tools can be influenced by their cognitive beliefs and emotional responses as well as contextual factors (Chiu, 2024). Moreover, there can often be a disconnect between an educator's positive perceptions of AI and an educator's actual use of AI systems.

The individual and contextual circumstances that shape teachers' attitudes include their experience, digital competence, and pedagogical beliefs. Based on these attitudes, teachers also interpret the nature of AI, and how it should be used in teaching and learning. Experience with technology has an important effect on attitudes. Teachers with experience of digital technologies, online learning environments or other educational technologies are generally much more likely to accept AI and to use it; greater familiarity reduces uncertainty, and the confidence they gain through familiarity can help them to experiment with new tools (Scherer et al., 2021). Teachers with little experience of technology may perceive AI as intimidating or complex and therefore resist or may try to avoid using it. Digital competence is yet another relevant aspect. This relates to teachers' ability to use digital technologies effectively, including competences related to processing information, communicating, creating content and problem-solving. Teachers with higher levels of digital competence have more positive attitudes to AI, feeling more confident in understanding and controlling the technologies (Redecker, 2021). For generative AI, this additional aspect also relates to critically evaluating the outputs of AI, crafting effective prompts, and using AI within pedagogically meaningful activities. Beliefs about pedagogy also determine how teachers view AI. Teachers who subscribe to a constructivist or student-centered vision of education are more likely to view AI as a tool that enhances learning experiences, democratic learning support for inquiry and collaboration, than as a disruptor to their existing plans for the instruction they wish to provide students (Chiu, 2024). Apart from

these individual aspects, the broader environment, including institutional culture, policy support, and opportunities for professional growth, are significant. Educators are much more likely to cultivate positive attitudes toward AI tools when provided appropriate training and support and empowered by conducive environments.

Cybersecurity researchers are given unique opportunity to meet one another at conferences, participate in research, and coordinate solutions with various authorities. These are necessary, however they do provide additional stress to already overloaded individuals who sometimes find it difficult to balance their academic/ career workloads. Teachers see both positive and negatives associated with AI systems which can lead to difficulty accepting them as viable interactive play-based tools in classrooms. While they view AI systems as having significant advantages such as providing more personalized instruction for learners because of the ability to generate criterion-referenced assessments, assist with timely feedback for learner's success in class, provide a means for automating high volume non-essential tasks (e.g., grading, testing), and the ability to utilize data to make decisions about instructional practices; many also report being concerned with aspects of these same systems that limit their willingness to use them as reliable sources of information to improve educational outcomes. A major source of concern expressed by teachers is based on reliability (i.e., the accuracy) of generative AI systems in the classroom and whether or not these systems can generate reliable output. To make matters worse, many teachers have experienced generative AI systems that did not act according to established or expected protocol/behavior and as a result raised questions concerning the overall effectiveness and usefulness of these tools due to the fact that teachers lack adequate input or explanation on how or why an output was produced. This creates a credibility barrier between teacher and

technology as there is no real evidence of successful or accurate outputs or viable rationale for why a system outputs information in a particular manner.

Ethical issues is another charge against AI and teachers raise the issues of data privacy, algorithmic bias, and abuse of the tool as their reasons for the "other" side of the fence. For this reason, Akgun & Greenhow cite that teachers practices threaten the critical thinking and academic honesty from the AI technologies, and the disproportionate impact of a biased algorithm on an underrepresented student population (Akgun & Greenhow, 2022). Some teachers raise the spectre of a loss of human interaction and feelings in their practice. Another aspect that occupies this concern is that of identity. Intelligent systems—infused by the generative—are expanding into the territory that was once solely occupied by the teacher as disseminator of knowledge. Some teachers appreciate this re-imagining of their positionality and see the value3 for students in development of the designer of the learning experience and facilitator of rubbed from where it belongs. Some feel their identity and role as under threat (Kasneci et al., 2023). Together this paints a picture of teacher attitudes in the round. Teachers do not occupy either "hope" or "fear" compute, but have different shades of beliefs and feelings coloured by many variables. This highlights the need for training and policy and ethical guidelines for teachers in how to leverage AI for good in their practice.

Pedagogical Adaptation and Instructional Transformation

The infusion of AI into education requires educators not only to adopt technology but also significant pedagogical adaptation and instructional transformation. Pedagogical adaptation is understood as ways in which teachers adapt or change their practices as well as their roles and the learning decisions they make as a response to emerging technologies. In the case of AI, the adaptation is extreme

since AI doesn't just lend support to existing activities but fundamentally alters the structure, dynamics, and epistemological nature of teaching and learning. Instructional transformation signifies the shift from teacher-centered instruction towards more flexible, data-driven and personalized instruction (Luckin et al., 2016; Chiu, 2024). Researchers are now arguing that pedagogical implications of AI are inextricably tied to its affordances (personalization, real-time feedback, predictive analytics and content generation), which can enable new methods of interaction, differentiation, and instructional design, but which also require teachers to develop new competencies and reconsider their pedagogical assumptions (Holmes et al., 2022). Hence, examining pedagogical adaptation involves understanding how AI is integrated into practice, how teacher roles evolve, and how pedagogical strategies in classroom settings change.

The potential for AI technologies in education raises significant challenges for teachers, too, calling into question conceptions of the teacher as primary providers of knowledge. In AI-enhanced learning, teachers are increasingly seen as facilitators, designers and mediators of learning experiences. In acting as facilitators, teachers help students navigate AI-supported learning environments, assisting them with interpreting AI suggestions, providing critical engagement with material, and eliciting higher level cognitive responses. Teachers "teach" less content and assist students more in knowledge construction through AI tools and social activities (Luckin et al. 2016). As designers, it is the teacher that bears the responsibility for the broad structure of a meaningful learning experience through pedagogically responsible AI integration. Choosing AI tools, structuring the task to make best use of AI affordances, and ensuring that the right activities occur for students to achieve learning objectives is the job of teachers in these contexts.

Instructional design work itself is likely to become highly redefined in generative AI contexts where the quality and effectiveness of generative AI outputs is tightly coupled with the quality of prompts and design of tasks (Chiu 2024). Beyond being intermediaries between AI and students, teachers become mediators who can decipher the accuracy and use of the AI's outputs to their students, clarify any inaccuracies and help keep the experience on track (Akgun & Greenhow 2022). Together, these new roles form part of a recognized trend in HCI away from a fully 'human' cognition where intelligent systems combine with different human actors towards achieving a kind of "shared" understanding. The opportunities for greater personalization and voice from this are tremendous and come along with important social issues concerning issues of professional integrity and authority.

The use of AI has in many cases led to 'novel classroom practices and pedagogies which seize on the opportunities presented by systems' (Holmes et al., 2022). These 'creative approaches to AI deployment' include 'more personalized and adaptive learning: methods that allow teachers to tailor content, pacing and feedback, making teaching more relevant and suitable to learners of differing abilities and backgrounds' (Holmes et al., 2022). These innovations are not without problems- teachers can easily slip away from actively teaching their students how to use AI in ways that aren't designed simply to lull them into mindless passivity and the deceptively simple AI model suggested by Mytrova and Kauffman requires teachers to engage students in critical interactions with AI-generated text. In instruction, the danger is always that AI could simply be used to feed students through the mill and they could become passive consumers, while many teachers may also be unaware of how to incorporate it into instruction in ways that enable creativity, ethics, and criticality. For example, students could compare the output of different AI and think through their limitations through critiques.

Issues related to determining academic integrity for students where AI may observe a classroom or may be used in explicit or oblique ways may not always be so clear (Chiu, 2024). Other areas where reliable strategies and management for teachers are concerned with using AI to respond to practical issues in the classroom and develop appropriate expectations for students' use, ranging from maintaining high standards of integrity and ethics in educational environments to creating a culture of conscious usage of and engagement with AI (Chiu, 2024). AI could even open up new dimensions in inquiry-based and collaborative learning, where students think through ideas and theorize and hypothesize with AIs - having conversations with them and working through ideas, as the teacher facilitates and guides the process as the ideal of 'flexible and collaborative education' (Kasneci et al., 2023).

Implications for Practice and Policy

Rapid trends in the use of AI systems in education bring implications beyond classroom practice and those need to be thought through on how these tools fit into the design of institutions and systems. Where generative, or adaptive, AI tools begin to emerge, decision makers need to prepare for the pedagogical, ethical and organizational issues created by those new technologies becoming integrated. This section thus focuses on key implications on how educators are able to design their learning experiences, what professional development they will need in order to make good use of the tools, and how to make policy about them. Work on integrating AI into education and design systems around should begin with a human-centered and ethical foundation. We are going through a major change in practice as teaching tools integrate from being supplemental uses of technology, to the place where AI is integrated as core aspects of instructionally designed experiences. Educators need key competencies for critical evaluation of AI-based tools in light of pedagogical goals—using AI to enhance human interactions,

not replace them. Going from thinking about AI use cases for procedural uses in education to reflective and intentional incorporation of AI as a tool for aiding teaching/learning processes (Chiu, 2024).

A central takeaway of this article to be grasped by educators, is that they need critical literacy in AI so that they themselves can assess the output of AI systems, and know where its language might itself be biased or untruthful; on that basis they will teach students to critically grapple with the AI systems they encounter. Critical literacy in AI will be much more than technical proficiency, use of an AI system, but also ethical and data literacy and an appreciation of algorithmic limitations (Akgun & Greenhow, 2022). An educator, lacking these skills, risks careless infelicities with AI systems leading to misinformation, dependency on the AI system, or degraded learning environments. Incorporating AI in the classroom as instructional aids will change teacher methodology such as redesigning activities for personalized learning opportunities with generative AI, AI in formative assessment, computationality as collaborative inquiry, and AI delivering different instruction to students, e.g generative AI is used to support brainstorming and to create other content as well as use learning analytics data to determine real-time adaptive instructional decisions (Bond et al., 2024). Current practices must be organized so that AI encourages students' engagement and higher order conceptual thinking rather than increasing the number of kids who are consumers of information. On top of this, educators need to ensure the role of AI remains balanced between AI use and human-centered pedagogy of teaching maybe the use of AI can increase ours in an efficiency and join us in the classroom as a scalable tool but it cannot be relied on where human fidelity and warmth are needed. We educators must continue to facilitate more genuine learning experiences ourselves, using AI to help guide students in other factors of teaching and

learning like agency, creativity and critical thinking (Luckin et al., 2016).

Building educators competency with AI is then critical to teachers own professionalism. Particular focus is paid on responsiveness of teachers for their professionalism and the extent to which teachers continue to develop their own practice through competence training, indicating that this is also a priority for schools as institutions (Harris, 2012). Continuous professional development is critical to this. Current modes of training for teachers where teachers are trained in basic technology skills increases the complexity of being a teacher training them in basic technology skills is unlikely to equip them to deal with the complexities than arise from augmentation of existing pedagogies with further information technology (Redecker, 2021). Teacher professional development requires a more holistic framework, a framework that encompasses all three dimensions of technology, pedagogy and ethics. One major implication that comes from framing discussions on AI is that educators need to discursively represent themselves as engaged in the development of more sophisticated frameworks for AI-focused professional development that are focused less on teachers' use of AI tools than on the development of teacher ability in AI, AI-based learning design, and ethics related to AI. in the manner that teacher professional development also requires that teachers have personal contact with AI tools themselves, share insights from working in collaborative teams with other educators, and reflect on their own experience of using AI (Tan et al., 2025). The need to evolve will be reflected through the assumed need to evolve the educator as a new profession. For that evolution, teachers will need help in designing new pedagogies, a new professional identity and how AI fits into that in terms of curriculum as they will no longer be planning for students learning where possible but will likewise need to plan for how students might learn from AI systems

that are increasingly integrated into their lives (Chiu, 2024).With the pace of technological change, continuing professional development of teachers is vital in where teachers are constantly being provided feedback on development of their own capacity, skill set and in what regard they will be needing to plan. “that institutional backing of teachers’ professional training is expected to provide opportunities for teachers to develop their capacity for learning, the skills and competencies necessary to adapt to and use new learning technologies effectively, making time available for professional training, and assisting teachers to develop a collaborative community of practice” (Bond et al., 2023).

For systems to be integrated into the education system, national-level policies should be established that take into account issues of access, equity, and other issues of governance and ethics. Create proactive policies where you make it acceptable to use AI in an effective way, rather than wait until something goes wrong with the use of AI in education to create guidelines. You need laws to specify the ethical and regulatory implications around transparency, accountability, and fairness within AI, relating as to how you think about data privacy and issues around algorithmic bias and the responsible application of student data, for example. It has long been known that the use of generative AI raises the question of bringing up academic integrity and intellectual property (Akgun & Greenhow, 2022), and figures earlier made the point about the lack of guidelines for us creating with generative AI is similar to that of using generative AI technology for the generation of student work. For that matter, clear guidelines for each application of this technology need to be provided on a consistent basis so we know how to responsibly apply this form of technology in education toward ethical applications through transparency and accountability (Akgun & Greenhow, 2022). A key factor in that is equity and access. While AI could represent new opportunities for educational advancement and

improvement, if access to both the technology required for AI and the digital resources necessary to facilitate learning through AI is unevenly held, existing disparities in terms of equity and access will only widen, and new disparities will develop in respect to access to AI tech and the digital resources required to facilitate learning through AI by education systems on a system-wide basis (Holmes et al., 2022). As a result, in order to be responsive to the issues, policymakers will have to ensure there is equal access to AI tools, and that there is appropriate infrastructure to support the use of those tools by both students and teachers, and also promote the development of teachers skills and knowledge in respect to AI sets of knowledge and skills by embedding AI skills/competencies into teacher education curricula and/or standards stating clearly what the expectations for AI competencies are and providing resources to assist in the development and training of teachers who will be using AI products in their classrooms (Redecker, 2021). Further, the policy framework will have to help facilitate collaboration among all stakeholders engaged in the use of AI in Education, noting that only by collaborating can developers have wholesome discussions about and develop technology solutions toward what education would like to see in terms of objectives so that they do not simply develop a technology solution that does not serve those objectives meet (Luckin et al., 2016). Policymakers will then need to consider the long-term implications of how if at all AI will impact education and how they would possibly want to think about changing assessment practices, develop a new curriculum, and revisit what it means to prepare students for a fast-changing AI world in ways that protect core values around equity and inclusivity and human development but at the same time embrace innovative approaches to education and the new opportunities afforded by AI technology (Luckin et al., 2016).

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Akgun S, & Greenhow C. (2022). Artificial intelligence in education: Addressing ethical challenges in K-12 settings. *AI Ethics, 2*(3):431-440. https://10.1007/s43681-021-00096-7

Alfredo, R., Echeverria, V., Jin, Y., Yan, L., Swiecki, Z., Gašević, D., & Martinez-Maldonado, R. (2024). Human-centred learning analytics and AI in education: A systematic literature review. *Computers and Education: Artificial Intelligence, 6*, 1-23. https://doi.org/10.1016/j.caeai.2024.100215

Bond, M., Khosravi, H., De Laat, M., Bergdahl, N., Negrea, V., Oxley, E., Pham, P., Chong, S. W., & Siemens, G. (2024). *A meta systematic review of artificial intelligence in higher education: A call for increased ethics, collaboration, and rigour*. *International Journal of Educational Technology in Higher Education, 21*(4), 2-41. https://doi.org/10.1186/s41239-023-00436-z

Chiu, T. K. F. (2024). The impact of Generative AI (GenAI) on practices, policies and research direction in education: a case of ChatGPT and Midjourney. *Interactive Learning Environments*, *32*(10), 6187–6203. https://doi.org/10.1080/10494820.2023.2253861

Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: The state of the field. *International Journal of Educational Technology in Higher Education, 20*(22), 2-22. https://doi.org/10.1186/s41239-023-00392-8

Deng, R., Jiang, M., Yu, X., Lu, Y., & Liu, S. (2025). Does ChatGPT enhance student learning? A systematic review and meta-analysis of experimental studies. *Computers & Education, 227*, 1-35. https://doi.org/10.1016/j.compedu.2024.105224

Holmes, W., Bialik, M., & Fadel, C. (2022). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.

Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., et al. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences, 103*, 1-9. https://doi.org/10.1016/j.lindif.2023.102274

Lee, D., Arnold, M., Srivastava, A., Plastow, K., Strelan, P., Ploeckl, F., Lekkas, D., & Palmer, E. (2024). The impact of generative AI on higher education learning and teaching: A study of educators' perspectives. *Computers and Education: Artificial Intelligence, 6*, 1-9. https://doi.org/10.1016/j.caeai.2024.100221

Létourneau, A., Deslandes Martineau, M., Charland, P., Karran, J. A., Boasen, J., & Léger, P. M. (2025). A systematic review of AI-driven intelligent tutoring systems (ITS) in K–12 education. *npj Science of Learning, 10*(29), 1-13. https://doi.org/10.1038/s41539-025-00320-7

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson.

Luo, J., Zheng, C., Yin, J., & Teo, H. H. (2025). Design and assessment of AI-based learning tools in higher education: A systematic review. *International Journal of Educational Technology in Higher Education, 22*(42), 2-27. https://doi.org/10.1186/s41239-025-00540-2

Memarian, B., & Doleck, T. (2023). ChatGPT in education: Methods, potentials, and limitations. *Computers in Human*

Behavior: Artificial Humans, 1(2), 1-11. https://doi.org/10.1016/j.chbah.2023.100022

Redecker, C. (2021). European framework for the digital competence of educators: DigCompEdu. *Publications Office of the European Union*. https://doi.org/ 10.2760/178382

Scherer, R., Siddiq, F., & Tondeur, J. (2021). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach. *Computers & Education, 128*, 13–35. https://doi.org/10.1016/j.compedu.2018.09.009

Tan, L. Y., Hu, S., Yeo, D. J., & Cheong, K. H. (2025). Artificial intelligence-enabled adaptive learning platforms: A review. *Computers and Education: Artificial Intelligence, 9*, 1-15. https://doi.org/10.1016/j.caeai.2025.100429

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425–478. https://doi.org/10.2307/30036540

Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. *Expert Systems with Applications, 252*, 1-19. https://doi.org/10.1016/j.eswa.2024.124167

Williamson, B., & Eynon, R. (2020). Historical threads, missing links, and future directions in AI in education. *Learning, Media and Technology, 45*(3), 223–235. https://doi.org/10.1080/17439884.2020.1798995

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education. *International*

Journal of Educational Technology in Higher Education, 16(39), 2–27. https://doi.org/10.1186/s41239-019-0171-0


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