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Pedagogical Competencies in the Age of Artificial Intelligence: Social, Ethical, and Educational Perspectives

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Abstract

Three dimensions: digital transformation, pedagogical competencies, and ethical governance are used in this study to investigate the integration of artificial intelligence (AI) in teaching and learning. By applying a PRISMA-informed systematic literature review approach, the study synthesises theoretical and empirical research to provide an overview of how AI can change educational practices and teachers' professional roles. The review highlights how AI-powered technologies, such as machine learning, personalized learning systems, automated assessments, and feedback mechanisms, can positively address the evolving needs of teacher competence. The results show that integrating AI into teaching requires teachers to develop advanced digital and pedagogical competencies, as well as their ability to evaluate AI-generated outcomes responsibly, particularly concerning data privacy, fairness, and accountability. It also emphasizes the role of educational organizations in developing governance structures, professional development processes, and educational policies. By combining various research, this study presents a human-centered approach to AI integration and offers an overview for future research and practical applications in digitally transformed educational settings.

Keywords: digital education; teacher professional development; digital competence frameworks; AI-TPACK

1. Introduction

1.1 Background and Research Context

Pedagogical models have evolved over the years, from traditional pedagogies to learner-centred approaches. Technological developments, in particular Artificial Intelligence (AI), have also facilitated this shift. This development requires educators to acquire new competencies, such as digital literacy, instructional design expertise, and adaptable teaching strategies (Redecker, 2017). Given the above, it is urgent to critically analyze how AI is changing pedagogical competencies and educational practices. Existing research on this topic remains fragmented across technical, pedagogical, and ethical domains; hence the need for more holistic models to help educators and their organizations chart courses in AI-enriched learning contexts. The present study aims to fill this gap by reviewing the existing literature to map new competency needs and identify major dimensions of pedagogical transformation in the era of AI.

1.2 Artificial Intelligence and the Transformation of Pedagogical Practice

Increasingly, the use of artificial intelligence (AI) tools, intelligent learning systems, and personalized learning platforms is changing the educational environment. Smart tutoring systems, artificial intelligence-based LMSs and large language models like ChatGPT are some of the key contributing tools in the education ecosystem. The use of chatbots has also increased significantly, with students receiving personalized replies that help them decide on the right course to study and provide additional materials and learning content. Likewise, adaptive learning systems like Squirrel AI demonstrated that it achieved much better learning improvements by adapting the difficulty and delivery style of materials to students (Chen et al., 2020). Not only is access to information being transformed, but also the way we teach and assess. These systems have put personalized learning in the center of the stage, allowing users to access adaptive content adapted to their own rhythm, needs or level of understanding. Besides, AI aids teaching by automating repetitive tasks, tracking student progress in real-time and suggesting individual learning materials (Zawacki-Richter et al., 2019). For teachers, it is critically important not only to accept new technologies but also to develop skills that use AI as tools to create enjoyable and inclusive classrooms (Luckin et al., 2016; Slade & Prinsloo, 2013).

This technical development requires the repositioning of pedagogical skills. Nowadays, in education, there are more pressing demands than ever before for teaching methods to become more innovative. In addition to their work as educators, teachers now need technology literacy, the ability to critically evaluate AI-generated results, the ability to make thoughtful ethical choices and the proficiency in reading complex data—all skills that will be needed for better student support. Educators need knowledge and skills to effectively use artificial intelligence (AI) tools. And they need to do this ethically, with fair access for all and a humane education-led approach. Ultimately, teachers remain at the heart of AI-supported education, guiding

it in ways that nurture balanced learner development rather than reducing learning to mere technical efficiency (Hodaj, 2025).

1.3 Research Gap and Purpose of the Study

Despite the growing body of research examining artificial intelligence in education, existing studies tend to be fragmented across disparate disciplinary and conceptual domains. Prior research has systematically explored different areas of AI-related applications, including adaptive learning systems, automated assessment tools, and learning analytics, as well as broader ethical and governance concerns. The literature often lacks synthesis, positioning technological developments separately from pedagogical competencies and educators' practices. Specifically, a comprehensive synthesis focusing on the three dimensions of pedagogical change, competence frameworks, and ethical governance in AI-supported education is not available.

This study aims to fill this gap by undertaking a PRISMA-based systematic review that maps existing research on artificial intelligence in education from the perspective of pedagogical competencies. More precisely, it seeks to cover the thematic areas including digital pedagogical competencies, AI-enhanced learning systems, automated assessment and personalization, as well as ethical and governance frameworks. By providing an integrative thematic synthesis, the study aims to gain insight into the emerging competencies educators will require and to support the development of a knowledge base for people-centred ways to integrate AI into educational practice.

1.4 Research question:

1. How has the digital transformation of education impacted pedagogical skills?
2. How are educators' pedagogical skills growing alongside the exciting advancements in AI technologies?
3. What ethical and normative principles should guide how we incorporate AI systems into education settings?

2. Methodology

2.1 Research Design and Review Approach

This paper employs a systematic literature review and qualitative thematic analysis to examine how AI is reshaping pedagogical power, instructional practices, and ethical governance in education. The use of a systematic review design aims to enhance rigor and coherence in synthesizing a broader range of theoretical, empirical, and general literature. This framework is especially relevant to the emerging landscape of AI technologies and research on pedagogy, technology, and educational ethics. The review emphasizes conceptual rather than statistical integration in order to develop a focused, analysis-driven synthesis of accumulated work.

2.2 PRISMA-Informed Review Protocol

The process of reviewing studies followed the principles outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). These principles guided us at every stage of the identification, screening, eligibility assessment, and inclusion of appropriate studies, thus providing a transparent and reproducible process. The PRISMA-based screening process is summarized in Table 1.

Table 1. PRISMA- Study Selection

Stage	Description	Number of Records (n)
Identification	Records identified through database searching (Scopus, Web of Science, ERIC, Google Scholar)	n = 428
	Additional records identified through reference list screening	n = 24
	Total records identified	n = 452
Screening	Records after duplicates removed	n = 381
	Records screened (title and abstract)	n = 381
	Records excluded after title and abstract screening	n = 274
Eligibility	Full-text articles assessed for eligibility	n = 107
	Full-text articles excluded with reasons (e.g., not education-focused, insufficient methodological detail, non-peer-reviewed)	n = 45
Included	Studies included in the qualitative thematic synthesis	n = 62

2.3 Data Sources and Search Strategy

A literature search was performed using the academic databases Scopus, Web of Science, ERIC, and Google Scholar. These sources were selected to provide broad disciplinary coverage, including education, educational technology, learning sciences, and policy research. The search parameters were limited to content published from 2015 to 2025, as this period is characterized by an exponential rise in AI-related technological innovations applied in educational environments. Only English-language papers were selected for inclusion. Search strings were developed using Boolean terms, including:

- “Artificial intelligence” AND “education”
- “AI” AND “pedagogical competencies”

- "Digital pedagogy" AND "AI"
- "AI-enhanced learning systems"
- "Automated assessment" AND "AI"
- "Ethical frameworks" AND "AI in education"

Backward and forward citation tracking were used to identify relevant studies that might have been missed during the original database search.

2.4 Inclusion and Exclusion Criteria

Explicit inclusion and exclusion criteria had also been defined to ensure the relevance and quality of publications used in screening.

The following were specified as inclusion criteria for studies:

1. Discuss applications or implications of AI in education.
2. Focus on pedagogical skills, teaching methods, learning organizations, evaluation, or governance;
3. Provide empirical, theoretical, or systematic findings- based analyses;
4. Appear in the form of peer-reviewed journal articles, conference papers, or authoritative institutional reports.

Exclusion criteria were introduced to exclude studies that:

- Focused only on technical AI and nothing to do with education;
- Were commentaries, editorials, or non-scientific publications;
- Dealt with where the AI applications were outside school or out-of-school education;
- Were duplicates or incomplete entries.

2.5 Study Selection and Screening Process

After removal of duplicates, titles and abstracts were screened for study relevance. Articles that met the inclusion criteria received a full-text review to ensure the completeness of the concept mapping and methodological quality. This iterative screening process resulted in a final corpus of 62 studies for inclusion and analysis in the qualitative thematic synthesis. Data abstraction used a structured coding framework that included the following: basic information from each publication; educational domain; types of AI/education applications; pedagogical approaches adopted in AI applications for education studies; and reflections on ethical/governance issues. This was followed by a secondary interpretative thematic analysis designed to identify patterns and connections among the concepts presented in the studies.

Thematic categories identified through constant comparative processes of coding and refining:

(1) digital pedagogical competencies and teacher training;
(2) AI-enhanced learning management systems and instructional environments;
(3) systems for automatic evaluation, feedback and personalization;
(4) AI in education, ethics, and institutional governance.

The thematic analysis was guided by well-known theoretical constructs such as DigCompEdu, TPACK , and AI-TPACK to ensure conceptual complementarity with existing pedagogical models.

3. Results: Findings of the Systematic Review

3.1 Pedagogical Competencies for a Digitally Transformed Education

The reviewed literature indicates that the digital education shift calls for a radical reframing of pedagogical capabilities. Studies show that artificial intelligence can improve learning outcomes and promote student motivation, which is important for providing personalized education. Globalization has given rise to a new paradigm in education, emphasizing continuous learning, adaptability, and the development of skills essential for success in a globalized world (Zalli, 2024). Therefore, there is an increasing need for teachers to efficiently integrate modern technologies into their teaching. (Gjermeni & Prodani, 2024). In this setting, teachers are required to have both technical competency and pedagogical ability to integrate AI-augmented tools with teaching goals and student learning outcomes. The DigCompEdu framework has been discussed as a primary driver for describing educators' digital competence outlining six major aspects: professional commitment, resources, teaching, assessing, empowering learners, and enabling digital education (Redecker, 2017).

Within this framework, Technological Pedagogical Content Knowledge (TPACK) provides a lens for examining the complexity of the relationships among technology, pedagogy, and content knowledge in successful teaching practice (Mishra & Koehler, 2006).

With the advent and increasing importance of digital technologies like AI within education, educators' proficiencies have widened beyond digital literacy to include AI literacy, data-informed decision-making, and the critical analysis of algorithmic outputs (Redecker, 2017). Now, teachers are being asked to interpret AI-generated analyses, incorporate AI-designed instruction into their teaching, and administer digital assessments that emphasize security, equity, and pedagogy. This development represents a significant shift in educators' roles, from the transmission of knowledge to the facilitation of AI-powered learning experiences (Selwyn, 2019). The literature highlights that this role shift requires continuous professional development and strong support structures.

Introducing AI in education causes profound changes in pedagogical paradigms. This transformation extends beyond traditional educational models, to focus on more tailored, intuitive and information-based learning (Williamson & Eynon, 2020). AI-based educational tools enable adaptive learning, unlike the conventional teaching method, which is often uniform. This system personalizes the instructional flow and pace for individual students based on their needs and learning styles. Furthermore, the relationship between AI systems and human instructors needs to be continuously examined to understand how these AI technologies are affecting teacher-student relationships and changing classroom dynamics, potentially redefining traditional roles and forcing educators to adapt to new paradigms (Almaraz-López et al., 2023; Kallunki et al., 2024). The digitization of education necessitates a reconsideration of pedagogical methods. The pressure on teachers to improve their digital literacy and develop a flexible pedagogy that leverages new technologies and emerging educational models is growing.

3.2 AI-Enhanced Learning Management Systems and Instructional Environments

The next most commonly discussed theme among the reviewed studies is the role of artificial intelligence in learning management systems (LMS) and instructional platforms. AI-based LMS increasingly use machine learning (ML) in combination with predictive analytics to track learner engagement, detect at-risk learners, and suggest personalized learning content (Ifenthaler & Yau, 2020). Open-source platforms, such as Moodle, and commercial solutions, such as Canvas and Blackboard, have already begun integrating AI-powered tools to support learners and administrative activities. Empirical evidence also suggests that LMS optimized with AI enables automated development of course materials, translation, and personalization, thereby increasing effectiveness and engaging learners more effectively (Pardosi et al., 2024).

Current platform strategies focus more closely on continuous adaptation, where constant improvements ensure that instructional materials are closely aligned with students and their changing learning needs. This statement is consistent with Luo's (2023) findings on improvements in academic performance in Chinese classrooms. By leveraging rich data collected from various e-learning environments, these systems can conduct sophisticated learning analytics. These analytical characteristics of assessment are important for curriculum development refinement, whilst also providing the facility and capability to dynamically adjust assessments in a real time (Luan et al., 2020) The multipurpose roles of AI contribute to its ability to support task management and resource allocation as well as enhance decision making within educational organizations, this underscores the need for systematic ethical and technical considerations of AI enabled Learning Management Systems (LMSs) despite their benefits. Pardosi et al. (2024) demonstrated that it is possible to offer a personalized learning experience through an AI-based adaptive learning system that continuously analyzes learner behaviour and performance.

A wider use of AI in education management improves the student experience while providing educators and school leaders with insights essential to designing adaptive, personalized, and effective learning environments. The integration of AI into LMSs represents a significant advancement in education, particularly in higher education.

3.3 Automated Assessment and Feedback Mechanisms

The literature review reveals automated assessment and feedback as an important application of artificial intelligence in education, particularly in domains such as programming, problem-solving, and skills-based learning environments.

According to Yang (2023), machine learning methods can align consistently with human assessment results when evaluating the digital competencies of university instructors. This result highlights a potential use case for AI in higher education assessment that can be both timely and accurate. Automated systems can provide formative feedback at an institutional scale, thereby positively contributing to student learning by offering instantaneous, specific advice. By including AI-driven assessments, institutions can gain deeper insights into their educators' competencies, with references to areas for improvement. These systems rely on machine learning, natural language processing, and rule-based techniques to not only evaluate assignments but also provide formative feedback.

This transforms assessment into a part of the learning process, rather than a summative judgment (Paiva et al., 2022). A meta-analysis by Liao et al. (2024) demonstrated that learners' capabilities can be extended through human-machine feedback in intelligent learning environments when personalized insights are provided, thereby fostering higher-order thinking and deep learning. This automated feedback process enables students to reflect on their learning trajectory, thereby optimizing knowledge construction. In a similar vein, Zamprogno et al. (2020) underscore the importance of integrating formative feedback into automatically graded assessments. They contend that such feedback prompts students to recalibrate their strategies and deepen their conceptual understanding, rather than merely memorizing solutions.

As demonstrated by Qian and Lehman (2019), targeted automated feedback effectively addresses common misconceptions in introductory programming. Consequently, this reduces cognitive load on instructors and enables a more scalable teaching approach.

Algorithms use data analytics and machine learning techniques to adapt instructional content, pacing, and strategies to the needs of individual learners. By engaging in this practice, they establish an educational ecosystem in which the learning experience is continuously refined to meet diverse curricular needs and accommodate different learning styles (Major et al., 2021). Such systems not only reduce educators' administrative workload but also empower students to engage in self-regulated learning by providing instant, actionable insights into their progress. Student

performance data is analyzed by AI-based systems, and adaptive content is provided that is tailored to individual learning styles (Tapalova, 2022; Murtaza et al., 2022). Furthermore, integrating AI has the powerful potential to boost learners' emotional and cognitive engagement. Machine learning approaches, such as clustering, reinforcement learning, and neural network models, play a pivotal role in evolving these personalized education systems.

AI technologies have increasingly penetrated both formal and informal education sectors, catalysing significant changes in teacher roles and learner experiences (Popenici & Kerr, 2017). Advancements in generative AI have further expanded educational prospects by enabling the creation of dynamic digital content and adaptive learning environments (Grassini, 2023). Meanwhile, Pyżalski (2024) in his empirical research, demonstrates that effective use of generative AI demands a refined set of pedagogical skills, such as prompt writing and critical evaluation of AI-generated content, thereby necessitating an update in teacher competencies. Teachers now collaborate with AI to personalize instruction, monitor learning analytics, and provide differentiated support. For example, AI-driven platforms like Knewton and Squirrel AI utilize real-time data to adapt content to individual learners, freeing educators to provide targeted interventions (Chen et al., 2020).

As stated by Zawacki-Richter et al. (2019), educators must develop advanced competencies in interpreting learning analytics and designing instruction that aligns with AI outputs. The TPACK framework of Koehler & Mishra (2009) remains a relevant model, as it emphasizes the importance of integrating technological, pedagogical, and content knowledge in a balanced way.

Meanwhile, Redecker (2017) underscores the significance of digital pedagogical competence, as delineated in the European Commission's DigCompEdu framework, as a fundamental prerequisite for contemporary educators.

The Technological Pedagogical Content Knowledge (TPACK) model is a crucial framework for understanding and developing the comprehensive knowledge teachers need to skillfully incorporate technology into their instructional methods (Koehler & Mishra, 2009). This transformation has prompted the proposal of extensible models, such as the augmented TPACK framework. These models represent a significant departure from conventional pedagogical practices and underscore the necessity for pedagogical innovations. Lorenz & Romeike (2023) and Balta (2024) align their research with the AI-PACK model, which specifies the competencies required for effective AI use in teaching. At the heart of the framework is the restructuring of teachers' knowledge across three main domains. Ning et al. (2024) observe the rapid evolution of AI necessitates a dynamic understanding of technological knowledge, which must be continuously updated. The literature posits that educators' capacity to effectively integrate AI is contingent upon the iterative development of their AI-TPACK. In light of these evolving dynamics, it becomes essential to reconceptualize traditional teaching roles in the age of AI. To illustrate

this transformation, Fig. 1 maps the progression from traditional pedagogical roles of educators to AI-augmented functions across key areas such as teaching, assessment, feedback, inclusion, and curriculum design.

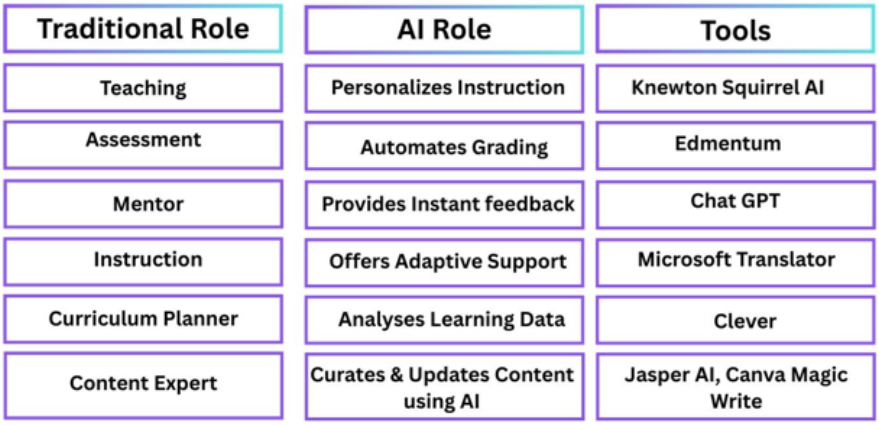

Figure 1. Transition from Traditional Pedagogy to AI-Enhanced Teaching Roles.

The incorporation of artificial intelligence (AI) into educational environments unveils a multifaceted landscape, rife with opportunities and ethical dilemmas that demand comprehensive frameworks and governance structures. Despite the clear benefits, integrating AI into education faces significant challenges, including data privacy, reliance on technology, algorithmic bias, and unequal access. One of the most significant ethical issues regarding the use of AI in education is safeguarding data confidentiality. The operation of AI systems requires a significant amount of personal information, including learning progress, performance records, behaviour patterns, and even biometric data. These datasets are often processed by third-party vendors with limited transparency, raising concerns about consent, misuse, and long-term data storage (Williamson & Hogan, 2020). It is important to strike a balance between the innovative potential of AI and concerns regarding data privacy, algorithmic bias, and the digital realm by developing ethical frameworks for the entire community. A stakeholder-inclusive approach that acknowledges the views of educators, students, developers, and policymakers is very important.

Collaborative efforts among these groups can foster a culture of trust that promotes the responsible integration of AI technologies. Institutions must implement policies that delineate guidelines for ethical AI use, encompassing fairness, non-discrimination, and transparency (Akgün & Greenhow, 2021). To address accountability, developing training programs for faculty and administrators is of utmost importance, with a focus on ethical AI use. Educators must understand the ethical dimensions and societal implications of AI applications to guide their implementation effectively (D'Souza et al., 2024). The diversity of interpretations regarding ethical principles across different regions and institutions calls for a harmonized yet context-sensitive approach to governance (Ulnicane et al., 2020).

Research suggests that continuous adaptation and refinement of AI technologies are necessary to align them with evolving pedagogical and ethical standards, ensuring that they genuinely meet the needs of educational environments.

The UNESCO Recommendation (2023) on the Ethics of Artificial Intelligence outlines foundational principles for the responsible deployment of AI in education, including human oversight, inclusiveness, and transparency. Similarly, the U.S. Department of Education's (2023) report Artificial Intelligence and the Future of Teaching and Learning stresses the importance of institutional readiness and leadership in guiding ethical innovation. The European Union's General Data Protection Regulation (GDPR) has brought these issues to light, but many educational systems lack robust data governance protocols (Slade & Prinsloo, 2013).

Several studies have documented how algorithmic systems can reinforce structural inequalities by embedding existing societal biases (Binns, 2018). In educational contexts, this may result in biased predictions about student performance, inappropriate interventions, or unequal access to learning opportunities. Zawacki-Richter et al. (2019) concluded that educators have to critically engage with the design and implementation of AI tools to prevent the perpetuation of discrimination based on gender, race, socioeconomic status, or learning ability. Using ethical algorithms and involving teachers in the design of AI tools can help reduce these risks.

Responsibility for ethical AI implementation extends beyond individual educators to institutional governance structures.

4. Discussion

4.1 Synthesis of Key Findings

Through the results of this PRISMA-informed systematic review, Artificial Intelligence goes beyond being a mere complementary educational technology to becoming a main factor in pedagogical change. Across the literature surveyed, AI continues to be presented as driving changes in instructional design and assessment practices, as well as in educators' professional roles. Unlike standalone tools, the introduction of AI results in a networked complementarity that impacts pedagogical capabilities and institutional processes.

The thematic synthesis shows that successful AI implementation in education depended on alignment among technological capacity, pedagogy, and ethical considerations. Digital pedagogical skills, AI-supported learning systems, learning assessment technologies, and governance structures, taken on their own, risk sustaining fragmented or overly technocentric practices.

But once integrated, they become more adaptive, learner-driven, human-guided pedagogical models. This synthesis highlights the need for systemic models that situate AI within a larger educational system, rather than treating it as an isolated new technology.

4.2 Implications for Pedagogical Theory

The findings are far-reaching for pedagogical theory, notably for well-established competency frameworks such as DigCompEdu, TPACK, and the newly emerging AI-TPACK models. The emergence of AI questions the sufficiency of general digital competency and of these competencies when decision-making is semi-automated and non-transparent, warranting further conceptualization.

Similarly, the TPACK framework emphasizes the importance of combining technology, pedagogy, and content knowledge. Nevertheless, the literature reviewed shows that AI gives rise to a new kind of technological understanding, with an important impact on how instructions and learners behave. These challenges are addressed in the AI-TPACK extensions, which emphasize the need for teachers to critically evaluate AI-generated content and manage human-machine interactions effectively. Overall, these results suggest that pedagogical theory needs to develop dynamic, adaptive models of competence that account for the evolving nature of knowledge domains in AI-enhanced educational environments.

4.3 Implications for Educational Practice and Policy

The results have important implications for practice and policy, highlighting the necessity of systematic teacher education, institutional governance, and educational leadership to enable responsible AI integration. Professional development initiatives should go beyond the acquisition of a technical skill to include pedagogical redesign, ethical reasoning, and data-informed instructional decision-making. Educators need opportunities to build their confidence, including in relation to AI-driven systems, especially in assessment and the personalisation of learning.

At the institutional level, governance structures are critical to promoting transparency, accountability, and accessibility. The literature emphasizes the need for explicit policies on data privacy, algorithmic bias, and oversight mechanisms, as well as leadership strategies that align AI adoption with educational values rather than those rooted solely in efficiency. Thus, policymakers and educational leaders take on a critical role in the development of AI-enhanced learning environments balancing innovation with responsibility.

4.4 Human-Centered Artificial Intelligence and the Future of Teaching

One of the main contributions of this work is to focus on human-centered AI as a principle for how we should teach going forward. The results indicate that AI should be conceptualized not as a replacement for pedagogical expertise but as a supportive system alongside human judgement, creativity, and the relational aspect of the educational process. Teachers continue to be crucial in interpreting AI-generated information, contextualizing learning opportunities, and protecting the ethical and emotive pillars of teaching and learning.

In the future of teaching in AI-enriched environments, it will be important to maintain the human touch at the center of pedagogical practice. This includes building trust, empathy, and critical reflection (all of which are impossible to automate). By empowering educators as "agentive users" rather than passive recipients, education systems can leverage AI's potential while ensuring pedagogical and social integrity. This framework is presented as a critical theoretical and practical perspective for the sustainable integration of AI in education.

5. Conclusions

5.1 Summary of Contributions

AI is revolutionizing the changing face of the education sector. This impact is characterized by changes in pedagogical approaches, the shift toward personalized learning paths and the advent of new curriculum designs.

Leveraging AI on a large scale in education is not just about improving the learner experience, but also about enabling educational administrators and educators with data-driven insights. This allows the development of personalized, adaptive, and efficient learning environments.

If the ethics of AI in education are to be upheld, educators need a careful bridge between their technology and their decision-making to maintain that human connection. But the responsibility does not rest solely with educators; it is also now time for schools and enterprises to step in with strong processes, clear rules, proper training, and oversight to ensure fair and responsible use of AI.

5.2 Limitations and Directions for Future Research

This paper is not without its limitations. First, the review is based solely on secondary data from peer-reviewed and reputable sources, and thus might not comprehensively cover emerging practices or experimental projects whose academic publications have yet to be published. Second, the focus on English-language publications may have limited the contribution of region-specific perspectives, for example, in places where AI use in education is emerging. Furthermore, the rapid progress in artificial intelligence suggests that many recent advances may not have been captured in the studies included in this review.

These limitations could be mitigated in future studies by including empirical methods, e.g., case studies, surveys, or mixed-methods designs, to investigate educators' experiences and practices related to AI competencies. Cross-level and cross-cultural comparisons would enhance our understanding of how AI penetration varies across contexts. Longitudinal studies to measure the development of pedagogical competencies and governance practices over time, in the context of the increasing use of AI tools, should also be considered. Future research can further advance a balanced, human-centered approach to AI in education that is both innovative and promotes pedagogical integrity and social responsibility.

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