Teacher Training and Artificial Intelligence: Aligning Skills and Competencies in Initial and Continuing Education Processes

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ABSTRACT
The rise of Artificial Intelligence (AI) in the educational landscape has significantly transformed pedagogical practices, demanding new skills and competencies from teachers. In this context, initial and continuing teacher training plays a crucial role in preparing educators to face challenges and leverage the opportunities brought by the integration of AI into teaching and learning processes. The approach used for this study is characterized as qualitative, a choice justified by its relevance in providing an in-depth understanding of complex phenomena in the scientific world. Two research procedures were employed in this study: bibliographic research and documentary analysis. The overarching goal of this study is to analyze how initial and continuing teacher training processes can align the skills and competencies required for AI-mediated teaching, highlighting challenges, opportunities, and innovative educational practices. The research emphasized that continuing education programs should prioritize training in competencies such as analyzing AI-generated educational data,

pedagogically integrating new technologies, and reflecting on ethical and inclusive practices in the use of these tools.

I. INTRODUCTION

The rapid evolution of Artificial Intelligence (AI) has brought profound changes to various sectors of society, including education. AI-driven tools, such as intelligent tutoring systems, personalized learning algorithms, and adaptive platforms, have become increasingly prevalent in classrooms, challenging traditional pedagogical models. These advancements, however, entail implications that extend beyond the mere adoption of technology. They demand a reconfiguration of the teacher's role, ethical reflection on the use of AI, and, most importantly, the professional development of educators to navigate these transformations effectively and critically (Glanville, 2024).

In this context, initial and continuing teacher education emerges as a cornerstone to ensure that educators develop the necessary skills and competencies to mediate teaching in a rapidly evolving technological environment. While initial training should equip future teachers to integrate AI from the outset of their careers, continuing education serves to keep these professionals updated and capable of incorporating technological innovations throughout their professional journeys. Understanding how these modalities of teacher training can align with the demands of the AI era is essential to guarantee high-quality, equitable education that meets the needs of the 21st century.

The approach adopted in this study is qualitative, justified by its relevance in providing an in-depth understanding of complex phenomena in the scientific domain. Two research procedures were employed: bibliographic research and documentary analysis.

The general objective of this study is to analyze how initial and continuing teacher training processes can align the skills and competencies required for AI-mediated teaching, emphasizing challenges, opportunities, and innovative educational practices. The specific objectives outlined are as follows: 1. To identify the primary challenges and opportunities brought by Artificial Intelligence to contemporary education, focusing on its impact on the teacher's role and the teaching-learning processes. 2. To investigate how initial teacher training can be structured to develop essential competencies for using AI as a pedagogical mediation tool. 3. To examine strategies and practices in continuing education that enable teachers to remain constantly updated and prepared to address the transformations driven by AI integration in education.

This article is organized into four main sections. The introduction presents the context, objectives, and relevance of the investigated theme. The materials and methods section details the qualitative approach adopted and the bibliographic and documentary research procedures utilized. The theoretical framework comprises three subsections that respectively explore the challenges and opportunities posed by AI in education, the role of initial training in building essential competencies for AI-mediated teaching, and the importance of continuing education in ensuring teacher readiness in the technological era. Finally, the conclusion synthesizes the results achieved, reinforcing the study's significance and proposing avenues for future research on the topic.

II. MATERIAL AND METHODS

The approach used in this study is characterized as qualitative, a choice justified by its relevance in providing an in-depth understanding of complex phenomena within the scientific domain. The qualitative approach allows for the exploration of meanings, interpretations, and contexts, offering a solid foundation for reflective and critical analyses. According to Creswell (2014), qualitative research contributes to knowledge construction in areas where social relationships, human perceptions, and cultural contexts play essential roles. Two research procedures were employed in this study: bibliographic research and documentary research. Bibliographic research is essential to theoretically support any scientific investigation, as it enables the analysis and dialogue with previously produced knowledge on the subject.

As Lakatos and Marconi (2017) state, bibliographic research expands understanding of the object of study and promotes the consolidation of well-founded approaches. For this study, updated scientific works related to teacher training and the integration of Artificial Intelligence (AI) into education were analyzed, ensuring the quality and relevance of the theoretical references used. Documentary research, in turn, complements the qualitative approach by enabling a detailed examination of official and private documents that directly address the object of study. This procedure is valued for its ability to provide concrete and updated data that contextualize the theoretical analysis.

According to Alves et al. (2021), documentary research is a powerful tool for investigating contemporary phenomena as it accesses original and relevant information on the topic. For this study, official publications such as the Brazilian Artificial Intelligence Plan (PBIA) 2024-2028 and the Reference Framework for Teachers' Digital Knowledge were consulted, along with informational content, such as the Ministry of Education (MEC) publication entitled MEC to Join the Brazilian Artificial Intelligence Plan, available from reliable sources. The combination of these methodological strategies ensured a rigorous and updated investigation, contributing to a well-founded analysis of teacher training in the AI era. This methodological integration not only reinforces the validity of the study but also ensures that its conclusions are grounded in consistent and relevant sources for the contemporary educational field.

III. THEORETICAL FRAMEWORK

The integration of Artificial Intelligence (AI) into education has led to significant transformations, challenging traditional pedagogical models and opening new possibilities for teaching and learning. In this context, it is essential to understand how teachers can be prepared, both in their initial training and through continuing education, to address the challenges and leverage the opportunities that AI offers.

Generative Artificial Intelligence (GAI) is a technological tool that facilitates understanding and interaction between humans and machines by employing language akin to human communication. Although GAI has existed since 1956, its use in generating images and texts (e.g., ChatGPT) has expanded significantly since 2022. However, ethical and social issues surrounding AI deployment evoke both excitement and apprehension. In education, the application of AI in teaching and learning processes, as well as its potential for critical use in pedagogical practice and interdisciplinary areas in adaptive and personalized ways, has become widespread. Intelligent Tutoring Systems (ITS) are a notable example of this trend (Giraffa, & Kohls-Santos, 2023).

This theoretical framework explores three central aspects of this theme. First, AI is discussed as both a challenge and an opportunity for contemporary education, analyzing its impact on pedagogical practices and the role of teachers. Next, the focus shifts to the initial training of teachers, emphasizing the development of essential competencies for using AI as a mediating tool in teaching and learning processes. Finally, continuing education is investigated as a cornerstone for teacher development, highlighting the need for strategies that enable educators to continuously adapt to technological innovations. These interconnected aspects provide a theoretical overview of teacher preparation in the AI era, aiming to contribute to the development of more innovative and inclusive educational practices.

3.1 Artificial Intelligence as a Challenge and Opportunity for Contemporary Education

Artificial Intelligence (AI) has emerged as a transformative element in contemporary education, presenting significant challenges and opportunities. Its application allows for personalized teaching, adapting content to individual student needs and promoting more engaging learning experiences. Recent studies suggest that AI can stimulate crucial skills, such as critical thinking, problem-solving, and creativity, by providing innovative and interactive learning environments (Oliveira et al., 2021). In Brazil, the Ministry of Education (MEC) is integrating the Brazilian Artificial Intelligence Plan (PBIA) 2024–2028, with an investment of R$ 817 million in educational initiatives. This strategy aims to incorporate AI strategically into the educational system, enhancing teaching processes and school management (Brasil, 2024a; Glanville, 2024).

However, the integration of AI into education also poses challenges. Ethical issues, such as algorithm transparency and potential biases in automated decisions, demand attention. Additionally, equipping teachers with the skills needed to use these technologies effectively is critical to maximizing AI's benefits and mitigating its limitations (Alves, 2023). The Center for Innovation in Brazilian Education (CIEB, 2019) highlights the importance of innovative and research-based approaches. It has issued technical notes to support digital teaching and contemporary education processes: - Self-assessment of Teachers' Digital Competencies (Technical Note Nr. 15); - Artificial Intelligence in Education (Technical Note Nr. 16); - Strategies for Remote Learning (EAR): Characteristics and Differentiation from Distance Education (EAD) (Technical Note Nr. 17); - Blended Learning and the Use of Digital Technologies in Basic Education (Technical Note Nr. 18).

AI models employed in education include Intelligent Tutoring Systems (ITS) that map teacher and student behaviors based on responses and offer personalized guidance. Examples include: - AVATUTOR (developed by the Laboratory of Intellectual Technologies at the University of São Paulo - USP); - CARNEGIE LEARNING (Cognitive Tutor, which provides personalized feedback to math students); - DUOLINGO (a language learning platform using AI techniques); - MATHWAY (an app offering step-by-step solutions for math problems using Cognitive Tutor). For teachers, challenges include keeping up with and utilizing technologies such as adaptive learning platforms (e.g., DREAMBOX, KNEWTON, SMART SPARROW, and DUOLINGO); speech recognition and natural language processing (e.g., IBM WATSON TEACHER ADVISOR); gamification, games, and simulation (e.g., FIFA and POKÉMON GO); prediction and recommendation models (e.g., COURSERA and KHAN ACADEMY); and virtual and augmented reality tools (Giraffa, & Kohls-Santos, 2023).

Thus, AI represents a valuable opportunity to revolutionize education, provided the challenges related to its ethical and effective implementation are addressed. Adequate preparation of educators and the formulation of inclusive public policies will be decisive in successfully integrating AI into the Brazilian educational environment (Brasil, 2024a; Duque et al., 2023).

3.2 Initial Teacher Education: Developing Essential Skills for AI-Mediated Teaching

Initial teacher education plays a crucial role in preparing educators to effectively integrate Artificial Intelligence (AI) into educational environments. The ability to understand and apply AI-based tools is essential for future teachers to fully harness technological innovations and promote more inclusive and personalized pedagogical practices. In Brazil, the Ministry of Education (MEC) has implemented significant initiatives to foster this integration. The Brazilian Artificial Intelligence Plan (PBIA) 2024–2028 stands out as a comprehensive strategy, allocating BRL 817 million to undergraduate programs, postgraduate scholarships, and technical training for teachers and staff. These resources aim to stimulate research and the development of skills related to AI, ensuring robust education aligned with contemporary demands.

Additionally, the PBIA foresees a total investment of BRL 1.15 billion from 2024 to 2028, directed toward the dissemination, training, and capacity-building in AI. This financial commitment underscores the importance of establishing an educational foundation that enables the critical and ethical use of emerging technologies (Brazil, 2024b).

Table 1 – Planned Investments in the PBIA (2024–2028)

Description	2024-2028
Immediate Impact Actions	R$ 435,04 millions
Infrastructure and Development of AI	R$ 5,79 billions
Diffusion, Training, and Capacity Building in AI	R$ 1,15 billion
AI for Improvement of Public Services	R$ 1,76 billion
AI for Business Innovation	R$ 13,79 billions
Support for the Regulatory and Governance Process of AI	R$ 103,25 millions
Total	R$ 23,03 billions

Source: Brasil (2024b)

The incorporation of AI into the educational process requires future teachers to develop a specific set of competencies. According to the Digital Knowledge Framework for Teachers, published by the Ministry of Education (MEC), it is essential for educators to acquire skills that enable them to use digital technologies with pedagogical intent, adapting them to their teaching practices (Brazil, 2023).

Moreover, initial teacher training should emphasize the teachers' ability to personalize the learning process through AI, providing more precise feedback to students and adapting their pedagogical approaches to individual needs. This perspective is supported by studies highlighting AI as an innovative pedagogical tool capable of fostering significant advancements in education. To consolidate these competencies, it is crucial that teacher training programs include subjects and practices that address the ethical and effective use of AI in education (Marcom, & Porto, 2023). This will ensure that future educators are prepared to face the challenges and seize the opportunities AI offers, contributing to the development of a more innovative and inclusive educational environment. The following, in Table 2, presents the key competencies required for AI-mediated teaching:

Table 2 - Essential Competencies for Teaching Mediated by Artificial Intelligence

Competency	Description
Pedagogical Use of AI	Teachers should be able to integrate AI tools into their teaching practices to enhance learning outcomes. This includes selecting appropriate AI-based resources to address various learning needs and goals.
Personalized Learning Design	Ability to personalize learning experiences for students using AI, adapting content and feedback to meet individual needs and preferences.
Data-Driven Decision Making	Competence in interpreting and utilizing data generated by AI tools to inform instructional decisions and improve student performance.
Ethical Use of AI in Education	Understanding the ethical implications of AI use in the classroom, including data privacy, security, and fairness, ensuring responsible use of AI technologies.
AI-Enhanced Assessment Techniques	Proficiency in using AI for formative and summative assessments, providing real-time feedback and tracking student progress effectively.
Collaboration with AI Systems	Ability to collaborate with AI systems, leveraging their capabilities to support collaborative learning environments, both online and in-person.
Continuous Professional Development	Engaging in ongoing learning to stay updated with evolving AI technologies, ensuring teachers' skills remain relevant and effective in an AI-enhanced educational landscape.

Source: Marcom and Porto (2023)

These competencies are essential for teachers to use Artificial Intelligence effectively and ethically within the educational context, contributing to the improvement of teaching and learning quality. They are also crucial, as they are necessary for establishing partnerships within the triple helix of innovation (Government, Academia, and Industry), aiming to foster the creation of innovation ecosystems that facilitate the integration of AI into teaching and entrepreneurship (Marcom, & Porto, 2023).

3.3 Continuous Professional Development as a Pillar for Teacher Update in the Age of Artificial Intelligence
Continuous professional development is essential for equipping teachers to effectively integrate Artificial Intelligence (AI) into the educational environment. In Brazil, initiatives such as the Brazilian Artificial Intelligence Plan (PBIA) 2024-2028, with investments amounting to R$ 817 million, aim to promote undergraduate courses, postgraduate scholarships, and technical courses targeted at educators, fostering research and the development of competencies related to AI (Brazil, 2024a and 2024b).

The integration of AI in education offers opportunities to personalize learning, automate administrative tasks, and provide more precise feedback to students. However, to fully capitalize on these benefits, it is essential that teachers update their skills and knowledge through continuous professional development programs that address the technical, ethical, and pedagogical dimensions of AI (Brazil, 2024a).

Recent studies highlight the importance of empowering teachers to identify and mitigate biases in AI systems, ensuring the ethical and responsible application of these technologies in education. Additionally, continuous professional development should emphasize the development of digital competencies that enable educators to critically and innovatively integrate AI into their pedagogical practices (Duque et al., 2023; Marcom, & Porto, 2023; Glanville, 2024).

Thus, continuous professional development emerges as a crucial pillar for teacher updating in the age of Artificial Intelligence, ensuring that educators are prepared to face challenges and seize the opportunities provided by these technologies in the contemporary educational context. Today, it is necessary for educators to be digitally literate, not only in using digital tools but also in understanding and being able to mitigate and identify biases in these tools, responsibly shaping the learning experience of their students in an inclusive and socially just manner, while facilitating and utilizing the data generated in a personalized way (Cukurova, & Miao, 2024).

The digitally literate educator must be competent in continuous learning and development, as they will need to stay updated with the emerging AI technologies and applications in the contemporary and future educational environment (Valério, & Santos Filho, 2024).

As de Valério and Santos Filho (2024, p.16) states:

[…] **the use of AI in education is an irreversible path**, and its application in the development of digital literacy is essential for **preparing teachers and students for the challenges of the 21st century**. Tools such as ChatGPT, Grammarly, Khan Academy, Google Classroom, and Canva, among others, offer numerous possibilities for personalizing learning, promoting autonomy, and fostering critical development of digital skills. (emphasis added)

Below, Table 3 presents the main updates necessary for teachers in the context of AI:

Table 3 - Main Updates Needed for Teachers in the Age of Artificial Intelligence

Update	Description
Digital Competence	Development of skills to effectively use digital technologies in the teaching-learning process.
AI Ethics	Understanding the ethical implications of using AI in education, including issues of privacy, transparency, and equity.
Instructional Design with AI	Ability to create learning experiences that integrate AI tools to meet the needs of students.
Educational Data Analysis	Ability to interpret and use data generated by AI systems to inform pedagogical practices and educational decisions.
Lifelong Learning	Commitment to continuously updating knowledge and skills in response to technological innovations and changes in the educational environment.

Source: Marcom e Porto (2023)

These updates are essential for teachers to effectively and ethically integrate Artificial Intelligence into their pedagogical practices, thereby contributing to the improvement of education quality.

IV. DISCUSSION AND CONCLUSION

This study aimed to analyze how initial and continuing teacher education processes can align the skills and competencies necessary for Artificial Intelligence (AI)-mediated teaching, highlighting challenges, opportunities, and innovative educational practices. Based on the findings, it was concluded that the research fully achieved its stated objectives, offering a significant contribution to the debate on AI integration in education and its impact on teacher training.

In the first subtopic, Artificial Intelligence as a Challenge and Opportunity for Contemporary Education, the research demonstrated that AI represents a duality in the educational field: while it provides powerful tools to personalize learning, it also poses challenges related to teacher training, ethics, and technological infrastructure. The study highlighted that, to leverage the opportunities offered by AI, it is crucial to overcome barriers such as unequal access to technology and resistance to pedagogical innovation.

In the second subtopic, Initial Teacher Education: Developing Essential Competencies for AI-Mediated Teaching, the findings revealed that initial teacher education plays a fundamental role in preparing future educators to engage with AI. The research emphasized the importance of including digital literacy, AI-mediated instructional design, and ethical considerations in the curriculum of teacher education programs. This approach ensures that prospective teachers are equipped to use AI-based tools critically and creatively.

In the third subtopic, Continuing Education as a Pillar for Teacher Development in the Age of Artificial Intelligence, it became evident that continuing education is indispensable for the constant updating of educators in response to rapid technological changes. The study underscored that continuing education programs should prioritize training in competencies such as analyzing educational data generated by AI, integrating new technologies into pedagogy, and reflecting on ethical and inclusive practices in using these tools.

Despite the advancements and insights provided by this research, gaps remain, highlighting the need for future studies. It is suggested to investigate how public policies can more effectively promote initial and continuing teacher education focused on AI use, particularly in contexts of technological vulnerability. Moreover, case studies examining AI-mediated pedagogical practices across different levels and modalities of education would be valuable to assess their impacts on student performance and teacher satisfaction.

Finally, a longitudinal analysis of how AI influences educational practices over time could provide a broader and more strategic perspective on the role of technology in education. This study, therefore, represents an important step toward understanding the challenges and opportunities AI brings to teacher training, contributing to the development of more innovative, inclusive, and 21st-century-aligned educational practices.

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