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Digital Technologies and Cultural-Historical Theory: epistemological foundations and implications for teacher education in contemporary times

Tecnologias Digitais e Teoria Histórico-Cultural: fundamentos epistemológicos e implicações para a formação docente na contemporaneidade

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ABSTRACT

The increasing presence of digital technologies and artificial intelligence in the contemporary educational context requires an epistemological reconfiguration of teacher education that goes beyond mere technical instrumentalization. This article, based on the Cultural-Historical Theory (CHT), offers a critical analysis of this framework's contributions to understanding technological mediation in the educational process, emphasizing the teacher's role as an active agent in the appropriation and resignification of digital artifacts. Drawing on a theoretical review and analysis of formative experiences, we argue that teacher education guided by CHT enhances reflective and humanizing pedagogical practices, in line with the challenges of the digital society.

Keywords: Cultural-Historical Theory. Teacher education. Digital technologies. Mediation. Computational thinking.

RESUMO

A crescente presença das tecnologias digitais e da inteligência artificial no contexto educacional contemporâneo instaura a necessidade de uma reconfiguração epistemológica da formação docente, que transcenda a mera instrumentalização técnica. Este artigo, fundamentado na Teoria Histórico-Cultural (THC), propõe uma análise crítica das contribuições desse referencial para a compreensão da mediação tecnológica no processo educativo, enfatizando o papel do professor como agente ativo na apropriação e ressignificação dos artefatos digitais. A partir de uma revisão teórica e análise de experiências formativas, defendemos que a formação docente orientada pela THC potencializa práticas pedagógicas reflexivas e humanizadoras, em consonância com os desafios da sociedade digital.

Palavras-chave: Teoria Histórico-Cultural. Formação docente. Tecnologias digitais. Mediação. Pensamento computacional.

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1. Introduction

The emergence of digital technologies and, more recently, artificial intelligence (AI), has driven profound transformations in the educational field, reconfiguring pedagogical practices, management models, and possibilities for inclusion. These transformations are situated within a historical context marked by the intensification of the so-called Fourth Industrial Revolution, characterized by the convergence of digital, physical, and biological technologies. In this scenario, education is being urged to rethink its foundations, processes, and purposes, since the presence of algorithms, automated systems, and digital platforms substantially alters knowledge mediation and the traditional roles of teachers and students.

However, this advancement, far from constituting a linear or contradiction-free movement, requires a critical analysis that considers its ambivalences and challenges, particularly regarding the ethical, social, and political issues underlying the use of these technologies. Technological advances in education, driven by AI, have fostered the personalization of teaching, enabling the adaptation of content and methodologies to students' individual needs. This personalization is expressed through educational platforms that use algorithms to map learning trajectories, suggesting activities and content that enhance engagement and the effectiveness of the educational process (Santos, 2025).

At the same time, the automation of assessments and the provision of immediate feedback have optimized educators' time, allowing them to focus on activities that require greater cognitive complexity and pedagogical interaction (Holmes et al., 2019). Nevertheless, the promise of more efficient and personalized teaching does not eliminate the risks associated with the homogenization of educational processes and algorithmic surveillance, which may compromise individuals' autonomy and the diversity of educational experiences (Williamson & Eynon, 2020).

Alongside these advances, pressing ethical considerations emerge. The implementation of AI in education, although rich in potential, faces challenges

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related to unequal access to technological infrastructure, especially in more vulnerable regions and in the Global South, where historical deficits in connectivity and adequate equipment persist (UNESCO, 2021). Furthermore, concerns arise regarding data privacy, algorithmic bias, and the potential dehumanization of pedagogical interactions, all of which demand robust regulation and an ethical framework committed to the protection of fundamental rights (Floridi et al., 2018). In this sense, it is essential that the adoption of these technologies be guided by principles that ensure transparency, fairness, and respect for diversity, preventing AI from becoming yet another vector for reproducing social inequalities (Eubanks, 2018).

One of the most promising aspects of AI use in education lies in its potential to promote educational inclusion. Through adaptive resources, such as reading software for visually impaired individuals or alternative communication systems for students with speech impairments, AI-based technologies can significantly expand access to knowledge and participation in the school environment (Ainscow, 2020). However, for these promises to materialize, it is crucial that their implementation be accompanied by public policies that ensure equitable access, preventing the widening of existing educational inequalities (UNESCO, 2021). Inclusion, in this context, cannot be conceived merely as physical or virtual access to technological resources, but as the effective possibility of participation, belonging, and meaningful learning for all individuals (Mello & Maia, 2022).

Another central element for the effective integration of AI in education concerns teacher education. The complexity of emerging technologies requires educators to develop digital and epistemological competencies that enable them to critically understand the pedagogical, ethical, and political implications of AI in teaching and learning processes (Redecker & Punie, 2017). Without solid and continuous training, there is a risk that teachers will be reduced to mere operators of technological systems, losing their central role as qualified mediators of knowledge. Therefore, teacher training

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must articulate technical, pedagogical, and critical dimensions to ensure that the use of AI is grounded in a reflective and humanizing perspective.

In this direction, the evolution of education through digital technologies and AI represents both an opportunity and a challenge. On the one hand, it opens possibilities for reimagining more personalized, interactive, and inclusive pedagogical practices, enhancing educational processes that respect individuals' singularities and expanding learning opportunities (Santos, 2025). On the other hand, it imposes the ethical imperative to confront structural inequalities, risks of surveillance and social control, and threats to privacy and autonomy (Eubanks, 2018). Thus, it is essential that the incorporation of AI in education is not conceived as an end, but to strengthen the humanizing dimension of education, empowering educators and students and reaffirming the transformative character of the educational process.

2. Cultural-Historical Theory and the Integration of Digital Technologies and Artificial Intelligence in Teacher Education for Basic Education

Teacher education in contemporary times faces complex challenges due to the rapid incorporation of digital technologies and, more recently, artificial intelligence (AI) into educational processes. In this context, Cultural-Historical Theory (CHT), developed by Lev Vygotsky and expanded by Alexei Leontiev and Vasili Davydov, emerges as a fundamental framework for understanding the impacts and formative possibilities of technologies in basic education (Vygotsky, 2007; Leontiev, 1983; Davydov, 1988). This perspective emphasizes that human development is mediated by cultural tools and social interaction, elements that become increasingly dense with the introduction of sophisticated technologies into everyday school life.

Thus, this chapter analyzes the interfaces between the progressive integration of digital technologies and AI and the education of teachers in basic education, articulating this discussion with the National Curriculum Guidelines (DCNs) for teacher education, from a critical and theoretically grounded perspective.

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Foundations of Cultural-Historical Theory Cultural-Historical Theory, developed by Vygotsky (2007), conceives the development of higher psychological functions as the result of mediation through cultural tools and signs, among which language occupies a central position. For Vygotsky, learning always occurs within a social context, with mediation as a fundamental condition for development. This assumption is intensified with the introduction of technologies that expand forms of mediation, enabling new modes of interaction in educational environments (Santos, 2023).

Leontiev (1983) deepened this perspective through Activity Theory, emphasizing that all human activity is oriented toward socially determined goals and mediated by tools, including digital technologies and AI platforms. Thus, teacher education, as a system of activities, involves diverse subjects who, mediated by cultural artifacts, construct knowledge in networked, situated, and dialogical ways (Engeström & Sannino, 2020).

Davydov (1988), in turn, proposed developmental teaching theory, arguing that teaching should precede and promote development through the intentional organization of situations that enable the formation of theoretical thinking. In this sense, pedagogical mediation must foster the transition from empirical to theoretical thought, supported by cultural tools that are now significantly expanded through digital technologies (Moura, 2010).

An important aspect to highlight is that the National Curriculum Guidelines (DCNs) for teacher education have progressively incorporated digital technologies, culminating in Resolution CNE/CP N° 2/2019, which establishes as an essential competency the understanding of digital phenomena and computational thinking, as well as their implications for teaching and learning processes (Brazil, 2019). This orientation underscores the need for teachers not only to master technological resources but also to critically understand their possibilities and limitations.

Similarly, the National Common Curricular Base (BNCC) has incorporated digital culture as a general competency, asserting that all students should understand, use, and create digital technologies in a critical,

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meaningful, reflective, and ethical manner (Brazil, 2017). This implies that initial teacher education programs must effectively integrate practices that connect technology use with pedagogical strategies that promote meaningful learning (Almeida & Valente, 2011).

From a cultural-historical perspective, technologies should be understood as mediating tools that expand learning and development possibilities while qualitatively transforming pedagogical practices. Digital technologies and AI thus function as cultural artifacts that expand the Zone of Proximal Development (ZPD), a central concept in Vygotsky's work, by enabling individuals to perform tasks they could not accomplish independently (Vygotsky, 2007).

Kurtz (2016) argues that meaningful integration of technologies requires overcoming a narrow instrumental view, proposing their incorporation as a constitutive element of pedagogical practices in a critical and contextualized manner. This view aligns with cultural-historical principles, according to which tools are not neutral but carry social and cultural intentionalities (Vygotsky, 2007).

Santos (2023) highlights that computers and the internet are symbolic tools that, as mediators of knowledge, must be integrated into teacher education processes in a reflective manner, not as trends or add-ons, but as resources that enable new forms of interaction and knowledge construction. Pastório *et al.* (2024) reinforce that the incorporation of ICT in teacher education must go beyond technical mastery, encompassing critical understanding and intentional use in pedagogical mediation processes.

Thus, the focus shifts from the question of *which technology to use* to *how and why to use a given technology to mediate a specific learning process*. This shift is essential to ensure that the integration of technologies into teacher education curricula is not superficial, but rather constitutes a transformative pedagogical practice (Moura, 2010).

Authors such as Engeström and Sannino (2020) have expanded Activity Theory to address complex and interconnected systems, highlighting expansive

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learning as a form that goes beyond individual knowledge acquisition, fostering the collective creation of new practices and knowledge. This conception is particularly relevant for teacher education, as it demands that educators and teacher educators collaboratively develop innovative teaching practices mediated by digital technologies and AI.

Schneuwly (2010) also emphasizes the relevance of Cultural-Historical Theory in contemporary education, defending the centrality of intentional mediation and the collective construction of knowledge. According to the author, the introduction of technologies in education requires reaffirming Vygotskian principles, particularly regarding the formation of teachers as critical and active agents in their practice.

The intersection between Cultural-Historical Theory and digital technologies in teacher education implies the need for conceptual updating, understanding technologies as mediating tools in learning and development processes (Kurtz, 2016). In this regard, the integration of technological, pedagogical, and content knowledge, as proposed by the TPACK model (Mishra & Koehler, 2006), is essential to ensure a holistic approach to teacher education.

Pedagogically, this requires methodologies that promote collaborative learning and experimentation, enabling future teachers to critically appropriate technologies (Almeida & Valente, 2011). The incorporation of digital platforms and AI systems can support the planning of activities that expand the Zone of Proximal Development of teacher candidates (Pastório et al., 2024).

Political Implications from a political perspective, the integration of technologies in teacher education must consider the structural inequalities that characterize the Brazilian educational system. Silveira and Vieira Junior (2019) point to a *dual reality* in access to technologies, with significant disparities between privileged and vulnerable contexts. Therefore, public policies must ensure adequate infrastructure and continuous teacher training to prevent technological integration from reinforcing inequalities (Brazil, 2019).

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Moreover, it is essential to prepare teachers as critical agents capable of questioning the ethical, political, and social implications of technologies, particularly regarding AI systems in education (Fernández-Muñoz, 2021). Cultural-Historical Theory, with its emphasis on conscious mediation and collective knowledge construction, provides a foundation for teacher education that promotes not only technical competencies but also ethical and critical dispositions toward technological transformations (Schneuwly, 2010).

From this perspective, the progressive integration of digital technologies and AI in teacher education should be understood as an opportunity for transforming pedagogical practices, provided it is guided by a critical, contextualized, and humanizing approach. The legacy of Vygotsky, Leontiev, and Davydov, updated by contemporary scholars, offers solid foundations for incorporating technology not as an end, but to enhance pedagogical mediation, expand human development possibilities, and contribute to a more democratic and inclusive education.

Within this theoretical horizon, the school ceases to be understood solely as a space for transmitting pre-established content and becomes a social space for the production, circulation, and reinterpretation of knowledge. This epistemological shift implies recognizing that educational processes are constituted through collective practices of meaning-making, in which subjects, languages, and cultural artifacts dynamically interact. In this context, digital technologies expand possibilities for interaction and intellectual cooperation, fostering learning networks in which students actively participate in the shared production of knowledge and access to diverse cultural and informational repertoires.

Thus, the pedagogical use of technologies cannot be reduced to an instrumental or purely technical perspective but must be understood within the broader sociocultural processes that shape contemporary society. Digital technologies are embedded in the cultural fabric of the present and therefore play a constitutive role in organizing educational practices, influencing how

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knowledge is produced, appropriated, and socially legitimized within the school context (Cole & Engeström, 1993).

Another central epistemological foundation concerns the concept of mediation through tools and signs, a core principle of Cultural-Historical Theory. For Vygotsky, the development of higher psychological functions occurs through the mediation of cultural artifacts that organize the relationship between the individual and the world, with language as the primary symbolic mediator in the formation of consciousness and thought (Vygotsky, 2001). In education, this perspective allows digital technologies to be understood as cultural tools that expand and complexify pedagogical mediation. Virtual learning environments, digital platforms, collaborative networks, and multimodal resources reshape interactions among teachers, students, and knowledge, creating conditions for more dialogical, collaborative, and cognitively distributed pedagogical practices.

In this sense, the presence of technologies does not replace teacher mediation but redefines it, repositioning the teacher as an organizer of learning contexts, a curator of information, and a guide for reflective engagement with digital tools. From this perspective, digital technologies are no longer merely auxiliary teaching resources but are recognized as cultural tools that actively participate in the reorganization of teaching, learning, and knowledge production processes in contemporary education (Wertsch, 1998; Engeström, 2001).

3 Digital Technologies as Cultural Artifacts: From Appropriation to Pedagogical Resignification

Understanding digital technologies as cultural artifacts constitutes a fundamental analytical key for critically reflecting on their integration into educational processes, particularly in teacher education. From the perspective of Cultural-Historical Theory, developed by Lev Vygotsky and further elaborated by scholars such as Alexei Leontiev and Vasili Davydov, technologies are not merely technical tools, but cultural mediations that, when appropriated by individuals,

DOI: http://doi.org/10.14393/OBv10.e2026-05

profoundly transform not only pedagogical practices but also ways of thinking, interacting, and producing knowledge (Vygotsky, 2007; Leontiev, 1983). This concept challenges reductionist and functionalist views that treat technology as a neutral instrument, highlighting its role as a constitutive element of social and cognitive practices.

Lantolf and Thorne (2006), revisiting Vygotsky's work, emphasize that every cultural tool, once internalized by the subject, reshapes reasoning processes and problem-solving strategies. In the educational field, digital technologies thus emerge as complex semiotic tools that not only expand communicative possibilities but also reconfigure processes of meaning-making and learning. However, the appropriation of these technologies does not occur automatically or uniformly; rather, it is conditioned by specific historical, social, and institutional contexts, marked by inequalities in access and by diverse pedagogical conceptions.

In this sense, appropriation should not be confused with mere use. To appropriate a technology implies not only technical familiarity but also its cultural and pedagogical resignification, situating it within educational practices aligned with formative goals and ethical and political values (Santos, 2025). Cultural-Historical Theory thus provides the necessary framework to understand the dialectical process through which individuals, in interacting with technological artifacts, simultaneously transform themselves and the tools they use, assigning them new meanings and functions.

For this reason, teacher education cannot be limited to training models grounded in a technical-operational logic that focuses solely on the superficial mastery of digital tools and platforms. This critique, already articulated by Demo (2000), remains highly relevant, especially in light of the proliferation of continuing education programs that restrict themselves to tutorials on technology use, without fostering deeper reflection on their epistemological, political, and ethical implications. According to Demo (2000), technological education must be grounded in a reflective stance oriented toward problematizing the processes of

DOI: http://doi.org/10.14393/OBv10.e2026-05

knowledge production and circulation, as well as the interests that shape the development and dissemination of technologies.

Furthermore, the integration of digital technologies into pedagogical practice should be understood as an opportunity to develop a situated and contextualized techno-pedagogical competence, as opposed to generic models detached from school realities. Mishra and Koehler (2006), in proposing the TPACK model (Technological Pedagogical Content Knowledge), argue that the pedagogical use of technologies requires the articulation of three domains of knowledge: technological, pedagogical, and content knowledge. Techno-pedagogical competence, therefore, cannot be conceived as a universal or monolithic construct, but rather as a practical form of knowledge emerging from the intersection between available resources, students' learning needs, and the teacher's pedagogical intentionality.

However, the uncritical adoption of the TPACK model must also be questioned, as it risks reinforcing a technicist view of pedagogical practice. As Selwyn (2016) and Williamson (2017) argue, discourses surrounding technology integration in education often obscure power relations, economic interests, and structural inequalities that shape the development and implementation of technological innovations in schools. From this perspective, teacher education must incorporate a critical dimension that addresses issues such as the platformization of education, algorithmic surveillance, and the risks associated with the commodification of educational data.

On the other hand, it would be a mistake to view digital technologies solely in terms of risks and challenges. They also enable new forms of pedagogical mediation, collaborative knowledge production, and reconfiguration of relationships among teachers, students, and knowledge (Almeida; Valente, 2011). Access to vast information repositories, participation in learning networks, and the use of multimodal resources expand opportunities for more interactive, dialogical, and personalized pedagogical practices, in alignment with Cultural-Historical Theory, which emphasizes mediation and social interaction as fundamental to human development (Vygotsky, 2007).

DOI: http://doi.org/10.14393/OBv10.e2026-05

However, this transformative potential of technologies is realized only when mediated by intentional and conscious pedagogical practices. As Santos (2025) highlights, the integration of digital technologies into education should not be guided by uncritical fascination with technical innovation, but by careful analysis of their contribution to meaningful learning and to the development of higher psychological functions. In this sense, the teacher must act as a reflective mediator, capable of selecting and adapting technological resources according to clearly defined educational objectives and explicit ethical values.

Moreover, the dynamic and evolving nature of digital technologies requires teacher education processes to foster a disposition toward continuous learning and pedagogical experimentation. As Kenski (2012) points out, the rapid pace of technological change demands not only the acquisition of specific technical skills, but above all the development of an investigative attitude that enables teachers to understand emerging trends, critically assess their implications, and incorporate innovations in contextualized and creative ways.

At the same time, it is essential to acknowledge that the appropriation of technologies in education occurs within contexts shaped by inequalities of access and political tensions. As Selwyn (2016) and Williamson (2017) note, enthusiasm for technological potential often obscures the material, institutional, and cultural barriers that hinder their effective use in public schools, particularly in countries marked by profound socioeconomic inequalities such as Brazil. Therefore, a critical reflection on digital technologies as cultural artifacts must include an analysis of the concrete conditions of their appropriation, as well as of the public policies that may facilitate or constrain their pedagogical use.

In this direction, it is crucial that teacher education fosters reflection on the political implications of adopting specific technologies, considering, for example, the risks associated with dependence on corporate platforms and the erosion of pedagogical autonomy (Selwyn, 2016). Cultural-Historical Theory, with its emphasis on conscious mediation and the historicity of

DOI: http://doi.org/10.14393/OBv10.e2026-05

human development, offers important insights for this reflection, highlighting that the transformation of pedagogical practices results not merely from the introduction of new artifacts, but from processes of resignification involving ethical and political choices.

It is also important to emphasize that conceiving digital technologies as cultural artifacts implies recognizing that their pedagogical appropriation is neither linear nor predetermined, but rather a complex process marked by resistance, reconfiguration, and innovation. Teacher education, in this context, should be understood as a space for problematization and experimentation, where educators can critically explore the potential and limitations of technologies, resignifying them in accordance with their pedagogical projects and the learning needs of their students (Almeida; Valente, 2011).

Thus, digital technologies, as cultural artifacts, should be understood and addressed in teacher education not as ready-made solutions or technical imperatives, but as potentially transformative mediations whose appropriation requires critical reflection, pedagogical contextualization, and ethical commitment. Cultural-Historical Theory, by providing a theoretical framework that emphasizes the plasticity and historicity of human development, enables a deeper understanding and orientation of this process, contributing to the integration of technologies in education in a truly transformative way, rather than yet another mechanism for reproducing inequalities and market-driven logics.

4. The Reframing of Pedagogical Practices Through Computational Thinking: A Teacher Education Example

Computational thinking, increasingly recognized as a central competency in contemporary education, constitutes a powerful tool for the reframing of pedagogical practices, especially when grounded in the perspective of Cultural-Historical Theory. By understanding computational thinking not merely as a technical skill, but as a culturally mediated form of thought, this perspective

DOI: http://doi.org/10.14393/OBv10.e2026-05

makes it possible to explore its formative potential beyond its instrumental dimension (Wing, 2006; Papert, 1980). In the teacher education example analyzed, which took place in 2023 at a Brazilian public university, this conception guided workshops designed for the preparation of basic education teachers, turning programming into a privileged means for expanding higher psychological functions.

In the workshops, teachers were invited to participate in activities that required the use of programming languages to solve contextualized pedagogical problems. This movement made it possible to reframe pedagogical practice, shifting it from the traditional model centered on content transmission to a problem-posing approach in which the teacher acts as a mediator and guide of learning processes (Vygotsky, 2007). In this context, the incorporation of computational thinking became a cultural tool that fostered the development of competencies such as logical reasoning, abstraction, and creative problem-solving.

By articulating programming activities with interdisciplinary themes, the workshops expanded the possibilities for curricular integration, promoting the overcoming of rigid compartmentalization among school subjects. This integration is consistent with the cultural-historical conception, which emphasizes the unity between cognitive processes and social practices, understanding learning as a situated, relational, and mediated phenomenon Santos (2025). In this way, computational thinking was appropriated by teachers not as an isolated content area, but as a tool capable of strengthening integrated and collaborative pedagogical practices.

However, the formative experience was not limited to the introduction of programming techniques, but also promoted critical reflection on the ethical, epistemological, and political implications of the use of digital technologies in education. This dimension is indispensable, since Cultural-Historical Theory understands cultural tools as carrying intentionalities and as constitutive elements of human formation Santos (2025). In this sense, the

DOI: http://doi.org/10.14393/OBv10.e2026-05

workshops enabled teachers to problematize the role of technologies in the school context, reflecting on both their possibilities and their limitations.

One of the most relevant aspects of the formative experience was the valuing of teacher agency in the construction and adaptation of pedagogical projects that integrated computational thinking. By affirming the centrality of the teacher as a critical mediator, the training broke with prescriptive and homogeneous models, promoting professional autonomy and strengthening teacher identity. This recognition of the teacher as an active subject in the formative process is one of the fundamental principles of Cultural-Historical Theory, which rejects passive conceptions of teaching and learning.

This collaborative dimension is coherent with the cultural-historical perspective, which understands learning as a socially mediated process grounded in practices of interaction and cooperation (Vygotsky, 2007).

Cultural-Historical Theory, by understanding technologies as cultural artifacts that mediate human activity, makes it possible for teacher education to go beyond the acquisition of technical competencies and to become a process of continuous and reflective professional development (Vygotsky, 2007). Thus, the introduction of computational thinking into pedagogical practices, when guided by this framework, becomes an opportunity for the construction of educational projects that promote the autonomy, creativity, and transformative development of subjects.

5. Teacher Education in the Face of Artificial Intelligence: Ethical and Epistemological Challenges

The progressive introduction of artificial intelligence (AI) into school environments constitutes one of the most significant transformations in contemporary pedagogical practices, raising new challenges for teacher education that must be addressed with theoretical rigor and ethical responsibility. Cultural-Historical Theory offers a critical and humanizing framework for understanding this phenomenon, emphasizing that technological mediations are

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not neutral, but rather carry social, political, and epistemological intentionalities that shape human development (Vygotsky, 2007; Santos (2025)).

The incorporation of AI platforms, such as adaptive learning systems, virtual assistants, and automated assessment algorithms, redefines forms of pedagogical mediation, transforming the nature of interaction among teachers, students, and knowledge. However, this transformation is not free from risks. It may enhance both processes of learning personalization and mechanisms of surveillance, standardization, and control over school practices (Williamson, 2017). Therefore, teacher education must prepare teachers not only for the technical use of these technologies, but above all for their critical understanding and ethical management.

From the perspective of Cultural-Historical Theory, AI must be understood as a cultural artifact that, once appropriated by subjects, reconfigures pedagogical practices and ways of thinking, but that can also be resignified and transformed within the educational process Santos (2025). This understanding avoids both technological determinism and technofetishism, promoting a dialectical view in which the teacher acts as a conscious mediator, capable of deciding on the relevance and limits of the use of AI-based technologies in the school context.

However, many teacher education programs still lack approaches that foster this critical reflection, limiting themselves to instrumental training in the use of specific tools without problematizing their epistemological and ethical implication. Such reductionism compromises teachers' professional autonomy, since they come to be seen as mere executors of practices defined by algorithms, rather than as critical intellectuals and producers of knowledge.

Teacher education in relation to AI must therefore include an analysis of the logics that structure algorithmic systems, so that teachers understand how these devices operate, which criteria guide their decisions, and what risks are associated with their indiscriminate application in education (Santos, 2025). Algorithmic opacity, a common feature of many AI-based

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solutions, poses significant challenges to transparency and accountability in pedagogical processes mediated by these technologies.

From an epistemological standpoint, the introduction of AI in education challenges traditional conceptions of teaching and learning by promoting a view centered on the logic of efficiency, predictability, and the quantification of educational processes (Williamson, 2017). Cultural-Historical Theory, by emphasizing the social, dialogical, and unpredictable character of learning, offers a critical perspective on this tendency, highlighting that human development cannot be reduced to predictive models or statistical behavioral patterns (Vygotsky, 2007).

Santos (2025) warns that the technological mediation promoted by AI tends to depersonalize teaching processes, subordinating them to external criteria and quantitative parameters that disregard the singularities of subjects and the specificities of educational contexts. Thus, teacher education must reaffirm the principle of human mediation as a central and irreplaceable element of pedagogical practice, resisting the replacement of the teaching function by automated systems.

Another ethical challenge associated with the use of AI in education concerns the protection of the personal data of students and teachers, which are often collected, stored, and analyzed by corporate systems without clarity regarding their uses, risks, and consequences (Santos, 2025). Teacher education must therefore include discussion of privacy, information security, and digital rights, fostering the construction of a culture of data protection and institutional accountability.

In addition, it is necessary to consider the risks of reproducing and deepening educational inequalities resulting from the application of AI systems, which may consolidate algorithmic biases and discriminatory patterns, especially affecting students from socially vulnerable groups (Eubanks, 2018). Cultural-Historical Theory, by understanding pedagogical practices as socially mediated and historically situated processes, offers elements for problematizing these

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asymmetries and for guiding the construction of fairer and more inclusive educational practices (Santos, 2025).

Teacher education in relation to AI must also promote reflection on the purposes of education and on the place of technologies within the formative process. The issue is not to reject AI a priori, but to understand under what conditions, with what objectives, and for which subjects it can be used in an ethical, pedagogical, and socially responsible manner (Santos, 2023). This position requires from teachers a critical stance and an ethical competence that goes beyond the technical dimension of training.

In this context, Cultural-Historical Theory offers a theoretical-methodological framework that values conscious mediation and the collective construction of knowledge, in contrast to educational practices that naturalize the centrality of technologies and subordinate teachers' work to algorithmic prescriptions (Vygotsky, 2007). Thus, teacher education must emphasize the need for teachers to act as active subjects in defining pedagogical strategies involving AI, preserving their professional autonomy and ethical responsibility.

The integration of AI into education also imposes challenges on the conception of curriculum, which must be rethought in light of the new competencies required for teaching practice and for students' formation within contemporary digital culture (Santos, 2025). Among these competencies are the ability to understand how AI systems function, to critically analyze their social and ethical implications, and to use these technologies creatively and responsibly in pedagogical processes.

Teacher education must therefore include content addressing not only the technical aspects of AI, but also its historical, cultural, social, and political dimensions, promoting an integrated and critical understanding of the phenomenon (Williamson, 2017). This approach is coherent with the assumptions of Cultural-Historical Theory, which understands human development as the result of the critical and reflective appropriation of available cultural tools (Vygotsky, 2007).

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Accordingly, it is necessary to emphasize that teacher education in relation to AI is a continuous and unfinished process, which must be guided by openness to dialogue, experimentation, and permanent reflection on pedagogical practices and on the meanings of education in contemporary society Santos (2025). Cultural-Historical Theory, by valuing the historicity and plasticity of human development, provides support for conceiving teacher education as a dialectical movement of professional and personal transformation, permanently traversed by new demands, challenges, and possibilities.

It is fair to say that the introduction of AI in education imposes complex ethical and epistemological challenges that require teacher education guided by critical, humanizing, and socially committed principles. Cultural-Historical Theory offers an indispensable theoretical framework for addressing these challenges, promoting the construction of pedagogical practices mediated by technologies but oriented towards the integral formation of subjects, the promotion of social justice, and the defense of human rights within digital culture (Santos, 2023; Vygotsky, 2007).

6 The Role of the Teacher as a Critical Mediator in the Use of Technologies

From the perspective of Cultural-Historical Theory, the teacher must be conceived as a critical mediator, responsible not only for the selection and use of technologies, but above all for their reflective and ethical appropriation, ensuring that their pedagogical integration is guided by the formative purposes of education rather than by external interests that often shape the development and dissemination of such artifacts (Santos, 2025).

In contemporary society, marked by the accelerated expansion of Digital Information and Communication Technologies, there is a growing tendency to naturalize technologies as inevitable and desirable solutions to educational challenges. This discourse, widely disseminated by technological corporations and governmental sectors, contributes to displacing the centrality of pedagogical action toward technological artifacts, relegating the teacher to a secondary role as an executor of procedures defined by

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algorithms and digital platforms (Williamson, 2017). Cultural-Historical Theory stands firmly against this view, reaffirming the centrality of the teacher as a critical mediator of the educational process.

Within this framework, the mediating role of the teacher implies the capacity to organize and guide teaching processes in ways that create conditions for the development of students' higher psychological functions through mediation with meaningful cultural tools (Vygotsky, 2007). Thus, when integrating digital technologies into practice, the teacher must critically evaluate their relevance, potential, and limitations, considering educational objectives and the concrete needs of learners.

This critical mediation requires understanding technologies not as ends in themselves, but as cultural means that may or may not contribute to specific pedagogical projects. In this sense, the teacher's appropriation of technologies must always be situated and contextualized, considering material conditions, student characteristics, and educational purposes, while avoiding both technofetishism and technophobia (Santos, 2025).

Accordingly, the teacher assumes the role of a curator and critical interpreter of knowledge and available resources, selecting and adapting them based on pedagogical and ethical criteria. This role is particularly relevant in the current context, characterized by an overwhelming volume of information and technological resources, which demand specific competencies for critical and responsible engagement. The absence of such mediation may lead to the uncritical adoption of technologies that reinforce inequalities, promote cultural homogenization, and undermine students' intellectual autonomy (Santos, 2025).

In this context, teacher education must be oriented toward the development of critical and reflective competencies, enabling educators to analyze technologies in their complexity, considering not only their functionality but also their epistemological, ethical, and political implications (Giroux, 2019). Cultural-Historical Theory provides solid foundations for this formation by

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understanding technologies as cultural artifacts that mediate social practices, rather than as neutral tools devoid of values and interests (Vygotsky, 2007).

As a critical mediator, the teacher must also be capable of resisting pressures that seek to subordinate pedagogical work to technological devices, asserting professional autonomy and reaffirming the centrality of human mediation in education. This resistance does not imply rejecting technologies, but rather appropriate them critically, guided by pedagogical principles and ethical commitments to students' integral development Santos (2025).

Moreover, the teacher plays a crucial role in fostering students' critical awareness of technologies, promoting the formation of reflective subjects capable of understanding their uses, limits, and social implications. This educational function is essential to ensure that students are not passive consumers of technologies, but active, creative, and responsible subjects capable of using digital resources to construct meaningful and transformative life projects (Santos (2025).

Critical mediation also involves problematizing the conditions of access to and use of technologies, recognizing the structural inequalities that shape educational systems and influence how different social groups appropriate digital tools (Selwyn, 2016). Thus, the teacher must act as an advocate for the right to quality education for all, calling for public policies that ensure adequate infrastructure, continuous professional development, and pedagogical resources for the effective integration of technologies in schools.

Another relevant aspect of the teacher's role as a critical mediator concerns the articulation between technologies and curricular content, avoiding both fragmentation and the artificial superimposition of digital resources onto pedagogical practices (Mishra; Koehler, 2006). Cultural-Historical Theory, by emphasizing the unity between teaching and development, guides teachers to design learning situations in which technologies are integrated meaningfully and intentionally, aligned with educational goals and the development of higher psychological functions (Vygotsky, 2007).

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Critical mediation is also expressed in the teacher's capacity to reflect on their own practice, continuously evaluating the effects of technological integration on teaching and learning processes and making necessary adjustments to ensure the quality and relevance of pedagogical actions (Santos (2025). This reflective movement is essential to avoid both the rigidification of decontextualized technological practices and the uncritical adoption of pedagogical trends.

In this regard, teacher education should promote the development of communities of practice, where educators can share experiences, collectively construct knowledge, and strengthen competencies for critical technological mediation (Wenger, 1998). Cultural-Historical Theory, by valuing the social dimension of learning and the importance of collaboration, provides theoretical and methodological support for such formative practices (Vygotsky, 2007).

The teacher's role as a critical mediator also entails engaging in dialogue with other educational actors, including administrators, families, and students, regarding the purposes and uses of technologies in education, fostering participatory and democratic decision-making processes Santos (2025). This dialogue is fundamental to ensuring that technological integration occurs in an ethical, transparent, and socially responsible manner, avoiding the imposition of solutions disconnected from the needs and expectations of the school community.

Furthermore, teachers must be able to identify and resist practices that aim to replace pedagogical work with automated solutions, defending the centrality of human mediation as an indispensable element in the construction of meaningful and transformative educational processes. Cultural-Historical Theory, by emphasizing the importance of social interaction and symbolic mediation in human development, provides strong theoretical support for this position (Vygotsky, 2007).

It is therefore essential to affirm that the teacher, as a critical mediator, contributes to the construction of a democratic, inclusive, and

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solidaristic digital culture that promotes respect for diversity, the valorization of cultural identities, and a commitment to social justice (Santos, 2025). This ethical and political perspective is indispensable to ensure that the integration of technologies in education does not merely reproduce hegemonic patterns but instead becomes a means for social transformation and the promotion of human dignity.

Thus, the role of the teacher as a critical mediator in the use of technologies constitutes a central axis for the development of meaningful, ethical, and socially committed pedagogical practices. Cultural-Historical Theory provides indispensable theoretical foundations for understanding and promoting this role, guiding teacher education toward the critical appropriation of technologies and the construction of a mediated, reflective, and transformative pedagogical praxis.

7 Final Considerations

Given the increasing presence of digital technologies in educational contexts, it becomes urgent that pedagogical and formative practices be critically and intentionally aligned, avoiding the risk that teachers and institutions are subsumed by the instrumental and market-driven logics that often accompany technological innovation. Rather than yielding to the seduction of uncritical adoption, it is essential to understand the historical evolution of technologies not as a neutral or inevitable process, but as a cultural construction that can and must be resignified and appropriated as an ally in educational projects oriented toward the integral development of individuals.

Teacher education in the digital age therefore demands far more than the acquisition of technical competencies related to the use of tools or platforms. It requires an epistemological and political understanding of technologies as cultural instruments that not only mediate but also constitute pedagogical practices and processes of human development. In this sense, Cultural-Historical Theory offers an indispensable theoretical framework for thinking about teacher education in a comprehensive and profound manner, emphasizing that all

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learning occurs through the mediation of historically situated tools and signs produced within social relations.

Furthermore, by emphasizing the social and relational dimension of development, the cultural-historical perspective helps to shift the focus away from technological apparatuses as ends in themselves, repositioning education as a space for meaning-making, subject formation, and the development of critical and creative individuals. This shift is essential for technologies to be effectively appropriated as allies in strengthening inclusive, reflective, and humanizing pedagogical practices, rather than as devices that reduce teaching to a merely operational function or threaten teachers' professional autonomy.

Thus, the construction of teacher education grounded in these assumptions enhances the teacher's role as an agent of social transformation, capable of resignifying digital technologies in accordance with pedagogical projects committed to social justice, equity, and the integral development of learners. This involves consolidating a conception of the teacher not as a mere executor of methodologies prescribed by algorithms or platforms, but as a critical intellectual and conscious mediator responsible for processes of cultural and educational mediation.

Critical mediation of technologies requires that teachers be prepared to understand the risks and tensions associated with their adoption, including processes of depersonalization, standardization of pedagogical practices, and the deepening of educational inequalities. At the same time, such training must enable them to recognize and explore the potential of digital technologies as tools that can expand access to knowledge, personalize learning, and promote students' intellectual autonomy.

Therefore, the challenge facing teacher education today is not simply to ensure the presence of technologies in schools, but to guarantee that such presence is guided by a critical, reflective, and situated perspective that recognizes technologies as historically produced cultural artifacts and as possible, rather than necessary, mediations for achieving specific educational

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goals. This approach requires teacher education institutions to develop curricula that articulate technical training with theoretical depth and ethical and political problematization of technology use in education.

It is thus reaffirmed that Cultural-Historical Theory, by offering a conception of human development that is simultaneously social, historical, and cultural, constitutes an essential theoretical framework for guiding pedagogical practices that integrate digital technologies in a critical and transformative manner. This perspective invites educators to overcome deterministic views and to construct educational practices that recognize both the potential of technologies and the need to establish limits, foster resistance, and reaffirm the centrality of human mediation in teaching and learning processes.

Within this horizon, teachers must assume themselves as active and central agents in guiding pedagogical processes, capable of deciding, in a grounded and ethical manner, when, how, and for what purposes to use specific technologies, always in relation to the integral development of their students. This conception demands initial and continuing teacher education that values reflection, collective knowledge production, and pedagogical experimentation as essential elements of a critical, creative, and transformative teaching praxis.

Ultimately, aligning pedagogical practices with the integral development of individuals, while remaining attentive to the risks of technological instrumentalization and domination, constitutes an urgent and profound political task. It involves ensuring that technological mediation in education is guided by humanistic values and by educational projects committed to building a more just, democratic, and inclusive society. This task is undoubtedly complex, yet indispensable for enabling teacher education and education as a whole to respond critically to the challenges of contemporary society.

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Tecnologías Digitales y Teoría Histórico-Cultural: fundamentos epistemológicos e implicaciones para la formación docente en la contemporaneidad

RESUMEN
El creciente protagonismo de las tecnologías digitales y la inteligencia artificial en el contexto educativo contemporáneo exige una reconfiguración epistemológica de la formación docente, que supere la mera instrumentalización técnica. Este artículo, basado en la Teoría Histórico-Cultural, ofrece un análisis crítico de sus aportes a la comprensión de la mediación tecnológica en el proceso educativo, destacando el papel del docente como agente activo en la apropiación y resignificación de los artefactos digitales. A partir de una revisión teórica y análisis de experiencias formativas, se defiende que la formación docente orientada por esta teoría potencia prácticas pedagógicas reflexivas y humanizadoras, en consonancia con los desafíos de la sociedad digital.

Palabras clave: Teoría Histórico-Cultural. Formación docente. Tecnologías digitales. Mediación. Pensamiento computacional.

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