Journal of Inclusive Methodology and Technology in Learning and Teaching
ISSN 2785-5104
Anno 6 n.1 (2026)

EDIZIONI UNIVERSITARIE ROMANE
editoria scientifica dal 1952

Educating for Artificial Intelligence in the Digital Society: Pedagogical Perspectives for Critical and Sustainable Citizenship

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Abstract: The digital transformation characterizing contemporary society, significantly accelerated by the Covid-19 pandemic, has profoundly affected educational contexts, calling into question teaching models, educational practices, and the very aims of education. In this scenario, Artificial Intelligence (AI) emerges as one of the most pervasive and ambivalent technologies, capable of influencing not only teaching and learning processes but also social, cultural, economic, and environmental dynamics.

This contribution offers a pedagogical reflection on education for Artificial Intelligence, situating it within a systemic and ecological perspective that conceives the relationship between human beings, the environment, and technology as a complex and interdependent network. Digital education is interpreted not merely as the acquisition of technical or instrumental skills, but as an educational pathway oriented toward the development of critical thinking, ethical awareness, and digital citizenship.

Particular attention is paid to issues of algorithmic citizenship, transparency and explainability of intelligent systems, social inclusion, and sustainability. In conclusion, the strategic role of schools and teacher education is emphasized in fostering critical and responsible competencies, which are essential for consciously inhabiting the complexity of contemporary digital society.

Keywords: Artificial Intelligence; Digital education; Digital citizenship; Critical thinking; Sustainability; School.

1. Introduction

Contemporary society is undergoing a profound and pervasive process of digital transformation that affects cultural, social, economic, and educational dimensions in a transversal manner (Floridi, 2015; Selwyn, 2019). Technological innovation, far from representing a mere instrumental advancement, increasingly appears as a paradigmatic shift capable of redefining ways of living, communicating, learning, and constructing meaningful relationships (Boyd, 2014). The acceleration driven by the Covid-19 pandemic has made this transformation particularly evident, showing how digital technologies are no longer merely occasional supports for human experience, but rather genuine living environments within which daily practices, cognitive processes, and identity dynamics are structured (Macchia & Torri, 2024).

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Within this complex scenario, Artificial Intelligence (AI) emerges as one of the most relevant and problematic phenomena of contemporary society (Cesaretti, 2021; OECD, 2021). Intelligent systems, increasingly embedded in everyday life, operate through algorithms capable of collecting, analysing, and interpreting large amounts of data, influencing decision-making processes in sensitive domains such as education, employment, healthcare, access to services, and democratic participation (Selwyn, 2019). AI thus represents not only a technical innovation, but also a cultural and social phenomenon that raises pedagogical, ethical, and political questions (Floridi, 2019; Malavasi, 2019).

The current historical phase is characterized by the progressive overcoming of the traditional dichotomy between the analogue and the digital worlds. As Floridi points out, we now live in an "Onlife" condition, in which human experience unfolds within a hybrid informational ecosystem where people, data, algorithms, and digital environments coexist and interact continuously (Floridi, 2015). From this perspective, technology can no longer be considered neutral or external to educational experience; rather, it assumes the role of a formative environment capable of shaping cognitive practices, social relationships, and forms of democratic participation (Floridi, 2019; Guardelli, 2024).

In light of these transformations, digital education cannot be reduced to a set of operational skills aimed at the effective use of technological tools. Instead, it must be understood as a complex educational pathway oriented toward the development of critical thinking, ethical awareness, and social responsibility (Bandura, 2001; Celot et al., 2021). Educating for Artificial Intelligence means supporting students and citizens in understanding the algorithmic mechanisms that increasingly govern access to information and automated decision-making processes (Panciroli & Rivoltella, 2023), fostering a conscious and reflective relationship with technology..

2. The Digital Society as a Complex Socio-Technical Ecosystem

The ongoing digital transformation can be interpreted as a process of profound social reorganization, in which technologies play a structuring role in shaping individual and collective practices (Latour, 2005). The growing interconnection between people, devices, and information has given rise to a socio-technical ecosystem characterized by high complexity, in which human actions are increasingly mediated by digital infrastructures and algorithmic systems (Floridi, 2015; Postman, 1993). Within this context, Artificial Intelligence emerges as a central node in a broader network involving economic, cultural, political, and educational dimensions (Cesaretti, 2021; OECD, 2021).

Bruno Latour's Actor–Network Theory provides a particularly effective interpretative framework for understanding this scenario (Latour, 2005). According to this perspective, the social is not produced exclusively by human action, but emerges from the interaction among a multiplicity of human and non-human actors that participate in the construction of reality. Technologies, and AI systems in particular, can thus be interpreted as socio-technical actors endowed with a form of agency, capable of influencing behaviours, decisions, and relationships (Floridi, 2019).

This view makes it possible to move beyond an anthropocentric conception of education, opening the way to a broader pedagogical reflection on educational responsibility in the digital age (Malavasi, 2019; Morin, 2001). If technologies actively

participate in shaping social practices, education cannot be limited to training individuals who are merely competent in using tools; rather, it must promote a critical understanding of the socio-technical networks within which such tools operate (Rivoltella, 2019).

Complementarily, Neil Postman's media ecology emphasizes how every technology introduces new symbolic and cognitive environments, modifying not only what we do, but also how we think, learn, and attribute meaning to experience (Postman, 1993).

3. Digital Education and Critical Citizenship in the Age of Algorithms

Within the socio-technical ecosystem outlined above, digital education assumes a strategic function in the formation of contemporary citizens. The pervasiveness of digital technologies and AI systems makes it increasingly evident that access to information, participation in public life, and the exercise of citizenship rights are mediated by algorithmic infrastructures (Celot et al., 2021). In this context, education is called upon to play a role of critical mediation, oriented not only toward the acquisition of operational skills, but above all toward the development of interpretative, reflective, and ethical capacities (Bandura, 2001).

Key European policy documents, including the Digital Competence Framework for Citizens (DigComp), emphasize that digital competences must be understood within a broad and integrated perspective (Vuorikari et al., 2022; Cosgrove & Cachia, 2025). Alongside technical abilities, cognitive, social, and ethical dimensions—such as critical thinking, the ability to assess the reliability of sources, awareness of algorithmic mechanisms, and understanding of the social implications of technological innovation—are recognized as fundamental (Rivoltella, 2019).

Schools represent a privileged context for the construction of these competences. As also highlighted by national guidelines on digital civic education, schools are required to promote education oriented toward the protection of fundamental rights, respect for democratic rules, and the responsible use of technologies (MIUR, 2020; Zanella, 2020). From this perspective, education for Artificial Intelligence cannot be confined to individual subjects or optional pathways, but must be integrated transversally across curricula (Guardelli, 2024).

Scholars such as Rivoltella and Panciroli argue that AI education should focus on understanding algorithmic processes and the logics governing data production, processing, and use (Panciroli & Rivoltella, 2023). The goal is not to train programmers or technical specialists, but rather citizens capable of critically questioning automated decisions, recognizing their limits, implications, and potential discriminatory effects (Buolamwini & Gebru, 2018). In this sense, digital education takes the form of education for responsibility, understood as the ability to adopt a conscious stance toward technologies and their social consequences (Bandura, 2001; Celot et al., 2021).

The critical dimension of digital education becomes particularly relevant in a context characterized by phenomena such as disinformation, fake news, and algorithmic manipulation of content. Recommendation algorithms tend to personalize users' informational experiences, creating closed communicative environments that may reinforce biases and polarisation (Selwyn, 2019; Boyd, 2014). Educating for critical thinking thus means fostering the ability to recognize these dynamics, evaluate information quality, and exercise conscious control over one's digital behaviours (Bandura, 2001; Celot et al., 2021).

4. Algorithmic Citizenship, Explainability, and Democracy

The growing centrality of algorithms in decision-making processes has given rise to new forms of citizenship, often referred to as algorithmic citizenship (Tomasello, 2023). This concept highlights how citizenship status and the exercise of rights are increasingly influenced by automated systems operating through data collection and analysis (UNESCO, 2021).

From access to public services to the assessment of academic performance, from personnel selection to user profiling, Artificial Intelligence significantly affects opportunities and possibilities for social participation (Obermeyer et al., 2019).

Within this scenario, critical issues emerge in terms of transparency, fairness, and accountability (Diakopoulos, 2016). AI systems—especially those based on complex machine learning models—are often characterized by a high degree of opacity, commonly referred to as the "black box" problem (Lipton, 2018). Such opacity makes it difficult to understand the logics guiding algorithmic decisions and to identify errors or biases embedded in training data (Buolamwini & Gebru, 2018).

From an educational perspective, explainability is not merely a technical issue, but a fundamental dimension of democratic citizenship (Lipton, 2018). Educating for Artificial Intelligence means developing students' ability to critically interrogate automated systems, demand explanations, and recognize the intrinsic limits of algorithmic decision-making (Diakopoulos, 2016).

Reflection on algorithmic citizenship also intersects with the issue of so-called algorithmic historical revisionism, namely the possibility that algorithms influence collective perceptions of the past through selective and distorted presentation of information (Bocci & Zona, 2024). Educating for digital citizenship therefore also entails fostering critical awareness of these processes and recognizing the active role of algorithms in shaping collective memory (Lévy, 2002).

From this standpoint, AI education acquires a democratic value, as it contributes to forming citizens capable of informed and responsible participation in the decision-making processes characterizing digital society (Biesta, 2015). Schools, as institutions devoted to the cultivation of critical thinking, are thus called upon to play a central role in promoting a form of citizenship capable of questioning algorithmic power and advocating for transparency, fairness, and social justice (Rivoltella, 2019; Celot et al., 2021).

5. Education for Critical Thinking and Responsibility in the Age of Artificial Intelligence

The complexity and opacity of Artificial Intelligence systems clearly demonstrate how critical thinking represents a key competence for contemporary citizenship (Celot et al., 2021). In advanced machine learning systems, decisions may be based on billions of computational processes, often rendering them incomprehensible even to their own designers (Lipton, 2018). This characteristic poses a significant challenge in terms of responsibility and accountability, as it becomes difficult to assign clear responsibility in cases of error or discrimination (Diakopoulos, 2016).

Within this context, education for critical thinking emerges as a fundamental resource for addressing the ambiguities and risks associated with automated decision-making (Bandura, 2001). Critical thinking, understood as the ability to analyse

information reflectively, evaluate arguments, and identify implicit biases, enables individuals not to passively accept algorithmic decisions, but to question the assumptions and consequences of automated choices (Celot et al., 2021).

From this perspective, AI literacy goes beyond technical understanding of systems and involves the formation of subjects capable of recognising the ethical, social, and cultural implications of technological innovation (Malavasi, 2019). Educating for critical thinking means developing the ability to interrogate training data, identify biases and discrimination, and understand the intrinsic limits of algorithmic models (Obermeyer et al., 2019).

Individuals educated in critical thinking are better equipped to actively participate in public debate on Artificial Intelligence, contributing to steering technological development toward socially desirable goals (Rivoltella, 2019). In conclusion, the alliance between education for critical thinking and Artificial Intelligence represents an essential condition for the construction of a fair, inclusive, and democratic digital society (Bandura, 2001). Through intentional and reflective instructional design, schools can foster the development of critical competences that enable students to consciously inhabit the complexity of the algorithmic age, exercising active and responsible citizenship (Rivoltella, 2019).

6. Artificial Intelligence, Inclusion, and Bias: Toward a Meta-Disciplinary Pedagogical Approach

The issue of inclusion represents one of the most delicate and complex nodes in the contemporary debate on Artificial Intelligence. The increasingly widespread adoption of intelligent systems across various domains of social life, including education, raises significant questions regarding equity, social justice, and the protection of fundamental rights (Cosgrove & Cachia, 2025; UNESCO, 2021).

On the one hand, AI offers significant opportunities for the personalization of learning pathways and for supporting individuals with special educational needs (Ancillotti, 2025). On the other hand, it risks amplifying pre-existing inequalities if it is designed and used without adequate attention to data quality and the ethical implications of algorithmic models (Buolamwini & Gebru, 2018).

One of the most critical aspects concerns the presence of bias in training data (Buolamwini & Gebru, 2018). As numerous studies have shown, AI systems learn from large datasets that often implicitly reflect the asymmetries, prejudices, and forms of discrimination present in society. From a pedagogical standpoint, these dynamics prompt a profound reflection on the role of education in promoting inclusion (Malavasi, 2019).

Educating for Artificial Intelligence also means developing critical awareness of the limits and risks of automated systems, fostering the ability to recognise and counteract algorithmic bias (Pagliara et al., 2025). In this perspective, education assumes an emancipatory function, aimed at making mechanisms of exclusion visible and promoting more equitable and responsible technological practices (Creati & Cuccaro, 2025).

Addressing the complexity of inclusion in the AI era requires a meta-disciplinary approach capable of fostering dialogue among diverse forms of knowledge and heterogeneous competences. As suggested by Obermeyer and other scholars, the design of inclusive intelligent systems cannot be entrusted exclusively to technical experts, but must involve educators, ethicists, social scientists, and representatives of the af-

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fected communities (Obermeyer et al., 2019). In educational contexts, this translates into the need to promote learning pathways that encourage interdisciplinary collaboration and critical reflection on the social implications of technological innovation.

7. Transparency, Explainability, and Inclusion in Educational Contexts

Transparency and explainability of Artificial Intelligence systems represent essential conditions for promoting inclusion and democratic participation. In educational settings, algorithmic opacity risks undermining users' trust and limiting the possibility of exercising conscious control over automated decision-making processes. The metaphor of the black box effectively captures this condition of opacity, in which the internal logics of intelligent systems remain difficult for humans to interpret (Spiller, 2021).

As Lipton (2018) argues, interpretability of machine learning models represents a complex challenge that cannot be resolved exclusively through technical solutions. Transparency is, in fact, a relative concept that must be assessed in relation to the intended users of systems and their contexts of use. What may be transparent to a researcher or developer may not be so for a student, teacher, or citizen (Lipton, 2018).

Consequently, education for Artificial Intelligence must promote a critical understanding of different forms of explanation and their purposes (Guardelli, 2024). From a pedagogical perspective, explainability performs a fundamental formative function, as it enables students to develop competences in interpreting and critically evaluating intelligent systems (Spiller, 2021).

Making algorithms explainable means providing users with conceptual tools to understand how decisions are made, which data are used, and which criteria guide processes of classification and prediction (Lipton, 2018; Diakopoulos, 2016). In this sense, transparency is not merely a matter of access to information, but a central element for the exercise of digital citizenship (Rivoltella, 2019).

Moreover, the adoption of open science and open-source practices can contribute to strengthening inclusion and trust in educational AI systems. Openness of models, source code, and development processes fosters greater user participation and enables more accurate evaluation of ethical and equity-related aspects of technologies. However, as several studies highlight, access to code and data alone is insufficient if not accompanied by adequate knowledge transfer. In educational contexts, this implies the need to train teachers and students to critically understand and use such resources (Coluzzi & Galatro, 2024).

8. Artificial Intelligence, Sustainability, and Ethics: An Ecological Vision of the Digital

Pedagogical reflection on Artificial Intelligence cannot overlook the ethical dimension and the issue of sustainability (Malavasi, 2019). Technological innovation produces effects that extend far beyond the strictly functional domain, impacting social relationships, the environment, and the living conditions of future generations (OECD, 2021).

As Malavasi (2019) emphasizes, education for AI must be embedded within an integral vision of the person, capable of holding together technological, ethical, and environmental dimensions. From this perspective, digital education can be inter-

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preted as ecological education, oriented toward understanding the interdependencies among human beings, the environment, and technology (Malavasi, 2019).

Sustainability concerns not only the responsible use of natural resources, but also the conscious management of informational and technological resources (OECD, 2021). AI systems require vast amounts of energy and data, with significant impacts on the environment and digital infrastructures (OECD, 2021; Malavasi, 2019). Educating for digital sustainability therefore entails developing critical awareness of the environmental and social costs of technological innovation (Morin, 2001; Malavasi, 2019).

Edgar Morin's theory of complex thinking offers a particularly suitable epistemological framework for addressing these challenges. The complexity of digital society requires an education capable of overcoming fragmentation of knowledge and promoting connections among disciplines, perspectives, and levels of analysis (Morin, 2001). Artificial Intelligence thus becomes a privileged object for developing transversal competences, such as the ability to navigate uncertainty, address complex problems, and reflect on the long-term consequences of technological choices.

Within this ecological vision of the digital, education assumes an orientative function, aimed at supporting the development of a balanced relationship between human beings and technology (Malavasi, 2019). AI, when consciously integrated into educational contexts, can enrich learning experiences and promote more sustainable and inclusive practices. However, this requires intentional pedagogical design capable of integrating technical and value-based dimensions, avoiding reductionist or deterministic approaches.

9. The Role of the School in Education for Artificial Intelligence

In contemporary digital society, schools emerge as privileged educational spaces for critically and consciously addressing the challenges posed by Artificial Intelligence (Ranieri, 2024). The experience gained during the Covid-19 pandemic clearly highlighted both the potential of digital technologies in ensuring educational continuity and the critical issues associated with their predominantly emergency-driven and instrumental use (Bocci & Zona, 2024).

This experience underscored the need to move beyond a technocentric conception of innovation and toward intentional and reflective pedagogical design (Simonetti, 2024). Educating for Artificial Intelligence does not mean merely introducing new tools or applications into school contexts, but rather rethinking the very aims of education in relation to ongoing cultural and social transformations (Toci et al., 2024).

Schools are called upon to promote education that enables students to understand how intelligent systems function, question their ethical and social implications, and develop critical competences for navigating the complexity of digital society. From this perspective, AI can become a powerful educational device, provided it is used as an object of reflection rather than merely as a functional support for teaching processes (Ranieri, 2024).

Integrating Artificial Intelligence into school curricula requires a transversal and interdisciplinary approach. The issues raised by AI cut across different domains of knowledge, involving scientific, humanistic, and social disciplines (Malavasi, 2019). Schools, as institutions devoted to the integral formation of the person, are thus called upon to foster dialogue among these forms of knowledge, promoting a systemic

understanding of technological phenomena and their educational implications (Simonetti, 2024).

10. Teacher Education as a Strategic Lever for Pedagogical Innovation

Teacher education represents a crucial element in effectively addressing the educational challenges posed by Artificial Intelligence. The development of teachers' digital competences cannot be limited to technical training in the use of tools, but must include critical reflection on pedagogical models, teaching practices, and the aims of education in the digital age (Biesta, 2015).

In the absence of adequate training, there is a risk of superficial or uncritical use of technologies, primarily oriented toward efficiency and standardization of teaching and learning processes (Selwyn, 2019). Contemporary pedagogy emphasizes the importance of reflective teacher professionalism, capable of continuously questioning the meaning of educational practices and their formative impact (Rivoltella, 2019).

In this sense, education for Artificial Intelligence can represent a significant opportunity to rethink the role of teachers as cultural mediators and facilitators of critical learning processes. Continuing professional development should foster the development of interpretative and ethical competences, alongside technical ones, enabling teachers to support students in understanding algorithmic dynamics and their social implications (Gulbay, Falzone, & La Marca, 2024).

As Biesta (2015) points out, authentic education always involves an element of risk and cannot be reduced to a set of measurable outcomes or performance indicators. The use of Artificial Intelligence in educational contexts, if guided exclusively by logics of control and standardized assessment, risks impoverishing educational experience and reducing the complexity of learning processes. Conversely, teacher education oriented toward reflexivity and responsibility can foster the use of AI in the service of human development, enhancing the relational and dialogical dimensions of education.

11. Pedagogical Implications and Educational Perspectives

The analysis conducted highlights how education for Artificial Intelligence cannot be considered a marginal or specialist field, but must be recognised as a structural component of contemporary educational systems (Ranieri, 2024). The pedagogical implications of this perspective are manifold and require a comprehensive rethinking of the aims, contents, and methodologies of digital education (Bocci & Zona, 2024).

First, there emerges a need to promote critical AI literacy, oriented not only toward understanding how intelligent systems function, but also toward reflecting on their ethical, social, and environmental consequences (Malavasi, 2019). Such literacy should be conceived as a continuous process accompanying individuals throughout their lives and involving diverse formal and informal learning contexts (Simonetti, 2024).

Second, education for Artificial Intelligence calls for the adoption of active and participatory teaching approaches capable of engaging students in processes of analysis, discussion, and problematisation (Rivoltella, 2019). Pedagogy oriented toward critical thinking, dialogue, and collaboration represents an appropriate educa-

tional response to the complexity of digital society, fostering the development of transversal competences essential for contemporary citizenship (Pagliara, Bonavolontà, & Mura, 2025).

Finally, the ecological perspective on the digital proposed in this contribution invites us to consider AI education as part of a broader educational project oriented toward sustainability and intergenerational responsibility (Malavasi, 2019; Morin, 2001). Educating for Artificial Intelligence means educating for care of the relationships among human beings, the environment, and technology, promoting a vision of progress grounded in respect for human dignity and social equity.

12. Conclusions

Education for Artificial Intelligence today represents one of the most significant pedagogical challenges for schools and educational systems as a whole. In a society increasingly permeated by technology, AI profoundly affects educational, social, and cultural processes, making a deep rethinking of the aims of education necessary.

As highlighted throughout this contribution, digital education cannot be reduced to the acquisition of instrumental competences, but must promote the integral formation of the person, oriented toward the development of critical thinking, ethical awareness, and responsible citizenship. When consciously integrated into educational contexts, Artificial Intelligence can become a powerful tool for pedagogical reflection and educational innovation (Panciroli & Rivoltella, 2023).

From this perspective, students have the right to be supported along an educational pathway that takes into account ongoing transformations and enables them to actively participate in digital society (Ranieri, 2024). Only through careful curricular design, continuous teacher education, and an ecological vision of the digital will it be possible to educate citizens capable of consciously inhabiting the complexity of the human–environment–technology relationship that characterises our time (Malavasi, 2019; Morin, 2001).

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