Special Issue

Engineering the Future Sociologically: a Call to Delve into Environmental Education Enhanced by Technological Innovations

FUORI LUOGO

Journal of Sociology of Territory, Tourism, Technology

Guest Editors

Norberto Albano
Sandro Brignone
Carmine Urciuoli

Editor in Chief: Fabio Corbisiero
Managing Editor: Carmine Urciuoli

YEAR VIII - Vol 22 - Number 1 - June 2025
FedOA - Federico II University Press
ISSN (online) 2723-9608 - ISSN (print) 2532-750X

Special Issue
Engineering the Future Sociologically: a Call to Delve into Environmental Education Enhanced by Technological Innovations

FUORI LUOGO

Journal of Sociology of Territory, Tourism, Technology

Guest editors
Norberto Albano
Sandro Brignone
Carmine Urciuoli

YEAR VIII - Vol 22 - Number 1 - June 2025
FedOA - Federico II University Press

ISSN (online) 2723–9608 – ISSN (print) 2532–750X

Summary

English text editors: Pietro Maturi.
Cover by Fabio Improta. Graphic elaboration by N. Albano using Stable Diffusion IA.

EDITORE

FedOA - Federico II University Press
Centro di Ateneo per le Biblioteche "Roberto Pettorino"
Università degli Studi di Napoli Federico II

Editorial responsibility
Fedoa adopts and promotes specific guidelines on editorial responsibility, and follows COPE's Best Practice Guidelines for Journal Editors.
Authorization of the Court of Naples no. 59 of 20 December 2016.
ISSN 2723-9608 (online publication) ISSN 2532-750X (paper publication)

Articles

In evaluating the proposed works, the journal follows a peer review procedure. The articles are proposed for evaluation by two anonymous referees, once removed any element that could identify the author.
Propose an article. The journal uses a submission system (open journal) to manage new proposals on the site.
http://www.serena.unina.it/index.php/fuoriluogo
Rights and permissions. For each contribution accepted for publication on “Fuori Luogo”, the authors must return to the editorial staff a letter of authorization, completed and signed. Failure to return the letter affects the publication of the article.
The policies on the reuse of articles can be consulted on http://www.serena.unina.it/index.php/fuoriluogo
Fuori Luogo is one of the open access journals published under the SHARE Interuniversity Convention.
Fuori Luogo is included in the ANVUR list of Area 14 scientific journals, class A for the sociological sectors, 14/C1, 14/C2, 14/C3, 14/D1.
Fuori Luogo is indexed in: DOAJ Directory of Open Access Journals - ACNP Catalogue code n. PT03461557 - Index Copernicus International ID 67296. The journal is part of CRIS Coordinamento Riviste Italiane di Sociologia.
Fuori Luogo is included in the LOCKSS (Lots of Copies Keep Stuff Safe) network of the Public Knowledge Project (PKP PLN)

Norberto Albano, Sandro Brignone, Carmine Urciuoli[1]

Engineering the Future Sociologically: Environmental Education and Advanced Technologies in the Age of Planetary Crisis

1. Sustainability, Technologies, and Educational Challenges: Towards a New Integrated Learning Paradigm

We are living in a historical moment marked by growing awareness – though at times evaded or contested – of the global environmental crisis. Climate change, biodiversity loss, and pollution constitute what the United Nations defines as the "Triple Planetary Crisis" (UN, 2021), a complex system of interconnected threats that represent the most critical challenge for the survival of our planet. These phenomena not only endanger natural ecosystems, but also profoundly affect human societies, altering the quality – and even the viability – of life, increasing inequalities, and generating social, economic, and political challenges.

The beginning of the 21st century has seen the warmest years on record globally since the Industrial Revolution, a period from which the impacts of anthropogenic activities have manifested with increasing pervasiveness. Global temperatures are approaching the 1.5-degree threshold above pre-industrial levels, as established by the 2015 Paris Agreement. This climate change, driven predominantly by greenhouse gas emissions from human activities, is causing increasingly frequent and intense extreme weather events: heatwaves, droughts, wildfires, floods, and storms that threaten communities, infrastructure, and essential resources. At the same time, biodiversity loss – accelerated by habitat destruction, pollution, and unsustainable exploitation of natural resources – is undermining the stability of ecosystems on which we depend. Air, water, and soil pollution have reached critical levels in several regions of the world, with severe consequences for public health and the well-being of local communities. Within this already alarming context, significant geopolitical events further exacerbate the crisis, with their effects reverberating globally.

Faced with such complex scenarios, where the reciprocal influences between environmental factors and human action are increasingly evident, a shared normative framework becomes essential as the foundation for global efforts toward equitable and ecologically sustainable development. The United Nations' 2030 Agenda provides an important programmatic and operational framework for global coordination. Its 17 Sustainable Development Goals (SDGs) and 169 targets (UN, 2015) offer an integrated vision in which ecosystem protection (SDGs 13, 14, 15) is inseparable – from among others – from socioeconomic equity (SDGs 1, 2, 5, 10) and inclusive, transparent institutions (SDGs 16, 17).

However, despite broad political consensus, the progress achieved so far remains insufficient. Recent reports estimate that only 15% of the goals are on track for 2030, while others are lagging behind, stagnating, or even regressing compared to their 2015 baselines, with substantial disparities across countries (UN, 2023; Nyhan, & Cryan, 2023). In this context, quality education (SDG 4) – particularly environmental education - emerges as a strategic junction: studies have shown that marginal increases in education levels are associated with significant reductions in carbon emissions and amplify the positive impact of renewable energy and energy efficiency on

1 Norberto Albano, PhD candidate: Northwest Italy Philosophy (FINO) PhD Program; 'Luciano Gallino' Behaviour Simulation and Educational Robotics Laboratory, Department of Philosophy and Education Sciences, University of Turin, norberto.albano@unito.it, ORCID: 0009-0007-2262-2598;
Sandro Brignone, PhD, Research Fellow, 'Luciano Gallino' Behaviour Simulation and Educational Robotics Laboratory, Department of Philosophy and Education Sciences, University of Turin, sandro.brignone@unito.it, ORCID: 0000-0001-7266-5405;
Carmine Urciuoli, PhD, Research Fellow, Department of Political and Social Sciences, University of Calabria, carmine.urciuoli@unina.it, ORCID: 0000-0003-0916-3669.

economic growth (Velempini, 2025; AlSagri, & Sohail, 2024). Education can thus act as a multiplier, facilitating progress on interconnected goals such as decent work (SDG 8), responsible innovation (SDG 9), and climate action (SDG 13).
The integration of advanced technologies – such as Artificial Intelligence (AI) and Extended Reality (XR) – has the potential to further accelerate the achievement of quality education globally, by expanding access to learning and supporting the realization of other SDGs (*ibid.*; Doshi *et al.*, 2024; Rane, 2023). AI-powered adaptive learning platforms, real-time automated translation, and assistive technologies offer concrete – perhaps unprecedented – opportunity to overcome barriers related to disability, language, or geographic location, promoting inclusive and personalized educational experiences (Fitas, 2025; UNESCO, 2024; Shireesha, & Jeevan, 2024). The impact extends beyond education: immersive environments based on virtual reality and intelligent tutoring algorithms enable the simulation of complex climate scenarios, fostering systems thinking and problem-solving skills oriented toward sustainability (Bakare *et al.*, 2024; Doshi *et al.*, 2024, *op. cit.*).
Both thematic pillars outlined thus far – environmental education and advanced technologies – possess significant transformative potential. They can influence both individual learning and collective cohesion, as well as the protection of ecosystems and the promotion of sustainable development models. When synergistically combined and appropriately directed, these domains can generate innovative solutions to the challenges posed by the planetary crisis, particularly in their most complex intersections, where education, technology, and sustainability converge. It is precisely on this ground that the contributions collected in this Special Issue of Fuori Luogo are situated, in response to the call entitled "Engineering the Future Sociologically: a Call to Delve into Environmental Education Enhanced by Technological Innovations". The articles presented here critically explore these intersections, offering theoretical insights, empirical analyses, and project-based reflections that interrogate – through diverse yet converging perspectives – the possibilities and contradictions inherent in the integration of ecological education and technological innovation. Readers will find in the following pages a reasoned map of the key challenges and emerging potentials within this complex and strategic landscape.

2. Environmental Education and Technological Innovation: Convergences and Tensions

Environmental education is recognized as a key instrument for addressing the ecological crises of the 21st century, promoting the knowledge, skills, and values necessary to build sustainable societies. Since the 1970s, this field has evolved by integrating multidisciplinary approaches, innovative technologies, and global collaborations. Today, environmental education is a multifaceted domain, yet its conceptual frameworks revolve – *nomen naturae congruum* – around the idea of fostering pro-environmental behavior. Arthur Lucas, one of the leading scholars in the field, noted that definitions of the term could be classified according to intent-based educational concepts: *about* the environment (focusing on the knowledge students should acquire), *in* the environment (emphasizing fieldwork and direct experience), or *for* the environment (encouraging conservation-oriented attitudes). Over time, these concepts have been incorporated into the broader framework of Education for Sustainable Development (ESD), which links environmental concerns with social and economic dimensions. This shift reflects a more holistic understanding of sustainability challenges and acknowledges that environmental issues are intrinsically tied to human well-being and economic development.
As one might expect, the variety of pedagogical approaches and teaching strategies used in environmental education – including those that incorporate advanced technologies – makes it difficult to establish a unified classification. This contribution therefore offers a brief review

of some of the main development trajectories that have emerged in both the literature and educational practice, with the aim of providing an initial critical orientation within a constantly evolving landscape. A central theme in many environmental education programs, especially at early levels of instruction, is the emphasis on *experiential* and *outdoor learning*, which engages students in direct and hands-on interactions with the environment. Activities such as school gardening, litter collection, field trips in natural settings, and, for secondary schools, environmental restoration projects, allow students not only to observe but also to design and improve their natural surroundings. These experiences foster a deeper connection and empathetic relationship with nature while strengthening problem-solving skills. Often, this education takes place in local contexts, focusing on the natural and cultural features of a community, through partnerships with local organizations or *service-learning* activities. Such experiences make learning more tangible and relevant to students' lives, facilitating the formation of social bonds, the recognition of natural contexts, and the adoption of pro-environmental behaviors.
However, several authors have pointed out that these experiences are not always practically feasible due to budget constraints, logistical limitations, or concerns about student safety. Educators sometimes face challenges in teaching abstract topics or issues distant from students' everyday lives, or they may choose to integrate traditional methods with increasingly accessible advanced technologies. Among the most recent technologies used in educational settings to promote environmental awareness and sustainability, the following can be identified (Hajj-Hassan *et al.*, 2024)

- Extended Reality (XR) Technologies – including Virtual Reality (VR) and Augmented Reality (AR) – offer immersive and interactive experiences that can significantly enhance learning about sustainability topics. VR can transport students to otherwise inaccessible or hazardous environments, allowing them to explore ecosystems, witness the impacts of climate change, or conduct experiments in virtual laboratories. AR overlays digital information onto the real world, enriching field experiences and facilitating complex investigative activities. AR applications such as "Environmental Detectives" engage students in simulated environmental investigations within real-world contexts.
- Videos and Podcasts are widely used as instructional supplements, especially in university settings. 360° videos, accessible via computer, tablet, or VR headsets, help visualize the impacts of climate change on glaciers or fragile ecosystems, enhancing awareness of the scale of these phenomena. Podcasts, typically episodic and concise, have emerged as a popular medium among younger generations for disseminating educational content.
- Online Platforms and Apps, whose importance grew significantly during the pandemic, have become nearly indispensable, particularly in remote or hybrid teaching environments. These tools facilitate the collection, monitoring, and sharing of ecological data, as in certain *citizen science* initiatives. For instance, *Google Earth* can be used to explore environmental disasters and support virtual fieldwork activities, which have been shown to improve students' awareness and pro-environmental attitudes, especially at the secondary level.
- Serious Games and Gamification Approaches are employed to engage students with sustainability topics and can enhance systems thinking and support for environmental policies. Gamification promotes environmental awareness and digital literacy among primary and early secondary school students, helping them internalize new habits related to water and energy usage, recycling, and the food production chain. Educational games can foster positive cognitive, emotional, and behavioral engagement during the learning process.
- Educational Robotics represents a promising frontier at the intersection of technology and environmental awareness. It is one of the most effective approaches for combining theory and practice in sustainability education. Activities such as robot construction, sensor usage, and direct monitoring of environmental parameters provide students with active learning opportunities to explore ecological phenomena. For example, sensor-equipped robots can

collect data on air quality, soil moisture, temperature, or pollution levels, or compare environmental data from different geographic areas via Internet of Things (IoT) platforms (Palmieri *et al.*, 2023). Additional applications include the design of "cleaning robots" capable of detecting and simulating waste collection, thereby raising student awareness of pollution and recycling. These experiences are particularly effective in primary and secondary education contexts, as they promote active, collaborative, and interdisciplinary learning. The convergence of educational robotics and environmental sustainability also reflects the evolution of STEAM curricula toward more ethical, inclusive, and SDG-oriented approaches. In this framework, robots are not merely technological tools but act as cultural mediators capable of facilitating interaction between technical knowledge, ecological imagination, and social responsibility.
- Artificial Intelligence, especially Large Language Models (LLMs) and generative AI, is beginning to make inroads into the field of environmental education, offering innovative tools for learning. AI can provide real-time information and analysis on environmental topics at both regional and global levels, encouraging ecologically responsible behavior. One study examined how students used generative AI tools to create comics about interspecies survival struggles (Sachyani, & Gal, 2025), drawing inspiration from locally observed situations. Platforms powered by advanced reasoning can offer interactive courses on renewable energy, climate models, waste reduction, and biodiversity conservation. This approach helps develop 21st-century skills such as critical thinking and creativity, while also fostering environmental citizenship. AI can support students in understanding sustainability topics by expanding their thinking to analyse complex problems and explore viable solutions, while also assisting teachers in adapting their methods and integrating new technologies into the curriculum.

It is important to emphasize that neither direct interaction with nature nor technology-mediated approaches alone are sufficient to generate effective sustainability education. A key challenge is to move beyond the mere transmission of ecological knowledge, which – while essential – is not enough to inspire collective action. It is crucial to cultivate pro-environmental attitudes and visions that lead to real changes in habits and lifestyles. In school settings, this requires didactic support that is both well-planned and responsive, capable of transforming stimuli into discussion, evoking emotions, encouraging questions, and promoting the search for solutions – in short, helping to make sense of experiences and turn them into meaningful actions. This suggests that approaches centered on students and based on direct exploration, supported by expert facilitators and well integrated into classroom practice, may be more effective in promoting pro-environmental attitudes. These "expert facilitators" could include not only human educators but also "intelligent agents" (AI systems) that stimulate reflection and encourage the adoption of responsible behaviors.

In the context of environmental education – especially when enhanced by advanced technologies – the adoption of an *eco-humanistic* and *critical perspective* is essential for cultivating authentic and responsible environmental citizenship. These approaches integrate thematic knowledge with ethical values, social justice, and a holistic understanding of the complex interactions between human beings and the environment. They recognize that the environmental challenges of the 21st century cannot be addressed solely through science and technology but require a profound shift in values and behaviors. They teach students to see the world as a complex system in which all parts influence one another, and to understand the causal relationships between their actions and environmental impact. The preservation of our planet is not merely an ecological issue, but a moral and social commitment that calls for intergenerational solidarity and respect for biological and cultural diversity.

3. Artificial Intelligence and the Promethean Dilemma: Toward a Critical Environmental Literacy

In delineating the conceptual framework of Engineering the Future Sociologically, it proves useful to retrace the long genealogy of automation, identifying key symbolic ruptures that – from the Industrial Revolution to the era of generative artificial intelligence – have progressively redefined the position of the human within the technical world. From this trajectory, three pivotal figures emerge – Charles Babbage, Günther Anders, and Stefano Rodotà – whose insights remain invaluable for interrogating the ambivalences of the planetary crisis and the educational responsibilities it entails. In conceiving the Analytical Engine in the 1840s, Babbage envisioned a universal device capable of absorbing the intellectual labor of human calculators engaged in the compilation of logarithmic tables for the British Empire. Matteo Pasquinelli has interpreted this experiment as a nexus between mechanical revolution and the extraction of value from the general intellect: the promise of unlimited computation, inaugurated by Jacquard's punched cards, which foreshadowed the logic of indexing and, in the long term, the appropriation of social data. The epistemic shift identified by Pasquinelli – from the anatomy of nineteenth-century manufacture to the predictive models trained on today's digital residues, such as social media, environmental sensors, and educational platforms – reveals how the algorithmic project is fundamentally political, inscribed from the outset within power relations and material, energy-intensive infrastructures.

Against this backdrop, in the 1950s, Günther Anders elaborated the concept of Promethean shame, the feeling of humiliation experienced by humans in the face of the superior performance of their technical creations. This emotion, Anders argues, reveals a Promethean asymmetry between the power to act and the capacity to represent its consequences: our imagination remains "out of sync," incapable of foreseeing the implications of the devices we design. Whereas in 1956 the ultimate test was the atomic bomb, today the same asymmetry reverberates in the training of large language models, whose billions of parameters obscure extractive chains of energy, rare earths, and invisible cognitive labor. In this sense, Promethean shame becomes a critical category for unmasking the rhetoric of "immaterial" AI, restoring to it its ecological weight.

In 2012, at the Permanent Seminar on "Ethics, Bioethics, and Citizenship" held at the University of Naples, Stefano Rodotà explicitly referenced Anders to denounce the ontological disproportion between the individual and techno-scientific apparatuses, calling for a new lexicon of rights capable of safeguarding human dignity within algorithmic society. This same critical thread reemerges in his later writings, where reflections on digital corporeality are intertwined with a growing awareness of the *homo dignus* threatened by processes of automated dehumanization. Rodotà thus shifts the focus from admiration or shame at the machine's power to the collective responsibility of defining limits, guarantees, and public purposes for technological innovation, shaping a "humanism of rights" that recognizes participatory governance of technology as an eminently democratic task.

Placing Babbage, Anders, and Rodotà within the same interpretive arc allows us to illuminate the nexus between technical enhancement, resource extraction – both material and cognitive – and the pressing need for critical ecological literacy. The threefold planetary crisis – climatic, biological, and polluting – demands that we move beyond the notion of AI as neutral or redemptive. On the contrary, intelligent systems must be read as total social facts, redistributing risks and opportunities, generating new inequalities but also unprecedented capacities to model environmental phenomena.

From this perspective, environmental education empowered by advanced technologies must be grounded in a critical genealogy capable of revealing the historical continuity between industrial and algorithmic automation, showing how every technological leap entails new forms of extractivism; in a material awareness that reanchors AI in its energy, mining, and labor footprint, thereby dismantling the illusion of weightless virtuality; and in an eco-digital constitutionalism that promotes a humanism of rights inclusive of planetary boundaries and oriented toward socio-technical design for climate justice. Only by adopting this posture can Artificial Intelligence be transformed from a vehicle of hybris into a cognitive lever for robust sustainability, in accordance with UNESCO's call for a Sustainable AI that harmonizes efficiency, equity, and ecosystem protection.

4. Artificial Intelligence Between Promises and Contradictions: A Critical Sociological Reading

In the contemporary landscape, Artificial Intelligence has emerged as a hegemonic signifier, a discursive catalyst that polarizes public and academic debate. It has become a site for the projection of palingenetic, almost messianic hopes for solving the aporias of late modernity, while simultaneously embodying systemic risks of no small magnitude (Di Matteo, & Zuccarelli, 2024; Razzante, 2024). Its most recent and pervasive incarnation in the form of large language models (LLMs) raises crucial questions for a critical sociology of the present, positioning itself at a key intersection between the acceleration of technological innovation, the imperative of environmental sustainability, and the reconfiguration of educational paradigms.

The fundamental contradiction that emerges from the current trajectory of AI development lies in its staggering energy consumption (Coeckelbergh, & Gunkel, 2025). The training of state-of-the-art language models and their large-scale deployment involves energy expenditures of systemic proportions. Recent studies, as reported in the 2025 Stanford AI Report, show that the carbon emissions produced during the training of AI models have increased exponentially: training GPT-3 in 2020 produced 588 tons of CO_2, GPT-4 in 2023 produced 5,184 tons, and Llama 3.1 405B reached 8,930 tons in 2024 (for context, the average American emits about 18 tons of carbon per year) (Maslej *et al.*, 2025, p. 28). The global data center infrastructure reached 415 TWh in 2024, with projections suggesting a possible doubling by 2030 – surpassing 945 TWh. If this energy demand is primarily met by fossil fuels, it results in substantial greenhouse gas emissions, further exacerbating the "Triple Planetary Crisis" already afflicting our time.

This energy consumption is accompanied by a process of systematic invisibilization of the material and social conditions that make it possible (Sissa, 2024). AI, in its infrastructural manifestation, is far from an ethereal or dematerialized entity; it possesses a substantial physical footprint and a deep ecological impact – often overlooked in dominant narratives focused on digital benefits. The supply chains for specialized hardware, from GPUs to dedicated servers, are entangled with extractive practices that negatively affect natural resources and human communities. The extraction of rare metals such as cobalt, lithium, and tantalum – crucial for electronic components – is frequently associated with deforestation, soil and water pollution, and exploitative labor conditions in mining regions. Downstream, planned obsolescence and the constant pursuit of more powerful hardware contribute to growing volumes of electronic waste laden with toxic substances, which, if improperly disposed of, risk contaminating ecosystems and communities, often in the world's peripheries.

Here, the relevance of a critical lens on "technocapitalism" emerges, an economic model in which digital technologies are embedded in profit-driven and accumulative logics, perpetuating extractive and colonialist dynamics in digital form. AI feeds on both a "data extractivism" – the exploitation of massive amounts of information often collected without proper consent or compensation – and a "material extractivism", whose environmental and human costs are systematically externalized. Moreover, the "invisible labor" of data annotation and content moderation – often precarious, underpaid, and psychologically burdensome – constitutes another element of the hidden materiality that underpins the seemingly immaterial edifice of AI.

Yet, in light of this critical picture, it would be intellectually dishonest and sociologically short-sighted to deny the transformative potential that ethically guided AI could unlock (Preeti, 2025; Hasas *et al.*, 2024). Among its most promising capabilities is the theoretical potential to optimize processes and reduce consumption across various sectors, including energy management and environmental monitoring. AI can analyse vast environmental datasets to detect emissions, monitor deforestation, or predict extreme weather events. However, prudent economists and scholars of technology cannot overlook the troubling spectre of the "Jevons Paradox": the efficiency gains made possible by AI, rather than leading to absolute reductions in consumption and impact, risk driving an aggregate increase in resource use within a growth-oriented system, thus nullifying specific gains and potentially worsening the overall ecological balance. While, as Maslej et al. (2025) show, the energy efficiency of machine learning hardware improves by approximately 40% each year, the total power required to train frontier models is effectively doubling annually. Power demands have risen from roughly 4,500 watts needed to train the Transformer model in 2017 to 25.3 million watts for Llama 3.1 405B in 2024, a more than 5,000-fold increase. It is this gap between individual efficiency and aggregate consumption that embodies the paradox, demonstrating how technological progress, in the absence of limits to growth, does not guarantee ecological benefit.

More ethically promising is AI's role in enhancing environmental education and awareness. LLMs' ability to process and communicate complex information in personalized ways, act as virtual tutors, analyse large volumes of environmental data, and generate interactive simulations opens up new possibilities for fostering critical ecological consciousness and promoting ecoliteracy suited to contemporary challenges. In an era defined by a multidimensional planetary crisis, this pedagogical function – if governed with wisdom and responsibility – could prove crucial in bridging the "human gap" in understanding our interconnection with ecosystems.

In this context, integrating artificial intelligence into environmental education is not merely a technical or operational issue; it raises profound questions about the nature of knowledge, inequalities of access, forms of educational agency, and the distribution of power in shaping environmental futures. A sociological perspective is essential not only for understanding the cultural and social dynamics in which AI is embedded but also for interrogating the models of society and subjectivity that it helps to shape.

AI is not neutral: it is built by actors, shaped by interests, and trained on data that reflect hierarchies, exclusions, and dominant narratives. Machine Learning models are opaque, both in their decision-making criteria and in the impacts they produce. In education, this may translate into decontextualized interactive and evaluative automatisms and into representations of the environmental world that are overly simplified or culturally biased. A sociological reading allows us to uncover the mechanisms of inclusion and exclusion that permeate AI use. Digital inequalities – which involve material access, cognitive skills, and cultural conditions – intersect with long-standing forms of marginalization, producing new educational divides. This is evident in the asymmetry between high-tech Western educational settings and under-resourced school systems in Africa or Asia that struggle to integrate AI due to infrastructural and linguistic barriers. Yet, these very contexts are also generating alternative models for AI integration: projects that value linguistic diversity, community inclusion, and collective intelligence. There are examples where AI is adapted to local educational ecosystems, becoming a tool to support learning, environmental awareness, and youth empowerment (Sachyani, & Gal, 2025; Kukutai, 2024). These are experiences that break with the logic of top-down technology transfer and instead promote the social co-design of technology.

Sociological reflection also allows us to question the cultural and epistemological transformations introduced by AI. Environmental education is no longer merely the transmission of ecological knowledge, but also a process of subjectivation that shapes identities, perceptions, and emotions. Technology acts as both a filter and amplifier of certain environmental imaginaries: which images of nature are conveyed? Which relationships between humans and non-humans

are emphasized or marginalized? Which forms of collective action are given voice, and which are silenced? Intelligent technologies raise pressing political questions: who decides what to teach and how? Which visions of the environment are deemed legitimate? Who has a voice in the technological design process? It is in this space that the social sciences can offer a decisive contribution – promoting participatory research practices, open models of governance, and normative frameworks capable of guiding technology toward public and inclusive ends.
Artificial Intelligence must therefore be understood in a profoundly dialectical light: a tool of immense transformative potential, yet intrinsically marked – at least in its current dominant configurations – by what we might call an "original sin" of material, energetic, and socio-cognitive unsustainability. It emerges as a contemporary *pharmakon*, in the Derridean sense: both poison and cure, remedy and toxin, whose nature depends entirely on dosage, context, and the awareness with which it is handled. The challenge before us is neither naïve faith nor a priori rejection, but the inauguration of a radical rethinking – a deep interrogation of the goals, conditions of possibility, and limits of AI development. Could AI, once it has helped foster a deeper ecological awareness and identified viable paths to genuine sustainability, be reined in and downsized from its current voracious, opaque, and energy-intensive forms? Will we be able to collectively engineer its future – through multilateral governance, participatory processes, and robust ethical principles – in a way that internalizes its ecological and social costs, transforming it from opaque problem into a responsible part of the solution?
This implies, as stated in the UNESCO Recommendation on the Ethics of Artificial Intelligence (2021), that the harmonious development of the environment and ecosystems must be recognized, protected, and promoted throughout the entire life cycle of AI systems – rebalancing the relationship between technology, society, and nature. Approaches such as Sustainable AI – which combine technical efficiency, social justice, and ecological sustainability – represent a fertile framework for rethinking the integration of AI and environmental education, rejecting both technological determinism and ethical-political inertia, and instead fostering a transformative alliance among critical knowledge, educational communities, and generative technologies.
Within this perspective, the present Special Issue of Fuori Luogo aims to explore – through the tools of social theory and philosophical reflection – the complex, ambivalent, and often contradictory intersections between AI, the environment, and education. It adopts a sociological-critical lens that does not shy away from deep awareness of the ethical and technological implications. Technology, far from being a neutral tool, acts as a powerful mediator between individuals and the environment, with the potential to redefine crucial aspects of our existence: from consumption patterns to everyday behavior, and ultimately, our fundamental relationship with the natural world.

5. Contents of the Issue

The call "Engineering the Future Sociologically: a Call to Delve into Environmental Education Enhanced by Technological Innovations" draws inspiration from the 12th edition of the World Environmental Education Congress (WEEC), held in Abu Dhabi in 2024, dedicated to issues of environmental education. The WEEC reaffirmed the urgency of rethinking education as a driver of ecological and social transformation, with a focus on cultivating active and informed citizens capable of leading the transition toward a sustainable future. The congress concluded with a compelling appeal for more ambitious action by 2030, in view of the deadline for the United Nations' Sustainable Development Goals (SDGs) and the Decade on Ecosystem Restoration.
This issue begins with a state-of-the-art mapping by Caterina Ambrosio and Dario Chianese in their contribution "Mapping Technology Usage in Environmental Education". Through bibliometric analysis using the PRISMA method and content analysis, the authors provide a com-

prehensive overview of how information and communication technologies are being adopted in environmental education. Their work classifies and systematizes key pedagogical practices that employ technology in this domain, highlighting the evolution of the field and the growing importance of tools such as geospatial information systems (GIS), augmented reality, and gamification. The article thus offers an updated picture of the sector's development, identifying trends, criticalities, and potentials for the socially equitable and conscious use of technologies in promoting sustainability.

Building on this framework, the second paper focuses on the urban environment as a privileged site for informal ecological learning. In "Learning Cities and Urban Ecosystems: Digital Technologies Fostering Informal Lifelong Environmental Education in Cities and Urban Participation", Marco Ingrassia explores how digital technologies – particularly augmented reality, participatory platforms, and video mapping – can enhance environmental education in cities, understood as dynamic ecosystems and spaces of active citizenship. Through two Italian case studies (*Superbarrio* and *Anima Mundi*), the author illustrates how these technologies can foster civic engagement, stimulate ecological empathy, and enable situated, continuous, and participatory learning processes. The third article, "ChatGPT and the Social Appropriation of AI on Discord", by Vincenzo Laezza, Arianna Petrosino, and Vincenzo Luise, adopts an ethnographic approach to study the social appropriation of generative artificial intelligence on digital platforms, focusing on *Discord*. The authors analyse emerging *prompt-making* practices as forms of collaborative work, informal learning, and the production of meaning and value, giving rise to bottom-up digital prompt-markets. The essay shows how the everyday use of AI is the outcome of collective, affective, and strategic negotiations – an example of the "social shaping of technology" – and opens up the possibility of a digital ecology based on distributed creativity and horizontal sharing of skills.

The fourth article "AI, Big Data, and IoT for Social and Environmental Sustainability in a Digital Transformation Course" by Antonio Opromolla, operates in the field of sociotechnical systems to examine how digital technologies – artificial intelligence, the Internet of Things, and Big Data – can contribute to sustainable development when interpreted within an integrated vision that values the co-evolution of technical and social factors. The author introduces the concept of "design sociology" as a methodology to govern complexity through human-centered approaches and co-design practices. Presenting a university course he developed, Opromolla offers a concrete example of how to integrate interdisciplinary knowledge, systems thinking, and ethical reflection in higher education, preparing the next generation to act as sustainable change agents in the digital age.

Finally, in dialogue with this systemic perspective, is the article "Ecoliteracy and Artificial Intelligence: Two Opposites for a Common Goal in Education" by Gianfranco Rubino, which addresses the theoretical and pedagogical challenge of combining ecoliteracy – understood as an ecological competence grounded in knowledge, empathy, and responsibility toward the environment—with the potential (and risks) of artificial intelligence. AI is described as a dual and paradoxical technology: on the one hand, a powerful tool for learning and ecological research; on the other, a system with significant environmental impacts in terms of energy consumption and resource extraction. The essay reviews key ecoliteracy theories (Goleman, Capra, Freire, Orr, etc.) and proposes an integrated model that, through ecopedagogy, merges the educational objectives of AI and environmental education in a transformative perspective. The proposal to build an experimental framework based on the direct use of AI language models represents a first step toward a pedagogy capable of enabling *ecological intelligence* in the digital era.

In the Readings section, this issue presents reviews of three volumes. The first, "Le emissioni segrete. L'impatto ambientale dell'universo digitale" (2024) by Giovanna Sissa, is reviewed by Mariella Berra. The book analyses, in a scientific yet accessible style, the often-hidden environmental costs of the digital universe, examining the full life cycle of technologies: from raw material extraction to the energy use of data centers and devices, down to the disposal of electronic waste.

Sissa proposes ecological transition strategies based on shared responsibility among producers, users, and policymakers, calling for an ethics of digital sustainability through integrated policies aimed at ecologically conscious technological transition.

In the second review, Giorgio Osti discusses "Digital Society" (2024) by Manuel Castells. The textbook offers a critical and up-to-date analysis of the digital society through a balanced and dialectical approach that integrates empirical data with sociological insight. Castells revisits the concept of the "network society," examining the impact of ICTs across different sectors – politics, labor, education – and addressing key topics such as digital inequality, surveillance, remote work, and social movements. The work stands out for its accessible yet rigorous language and its pragmatic outlook, which avoids easy pessimism while emphasizing the centrality of networks and the need for universal and meaningful access to digital technologies.

The third volume, "Educare all'IA. La sfida didattica dell'intelligenza Artificiale: ChatGPT e Gemini" (2024) by Massimiliano Badino, Fabio Aurelio D'Asaro, and Francesco Pedrazzoli, is reviewed by Emanuela Ricciardi. It offers schoolteachers a clear and practical guide to integrating generative artificial intelligence into educational practice, addressing regulatory aspects, technical operation, and ethical concerns. The authors provide concrete examples and pedagogical reflections aimed at fostering critical digital literacy, emphasizing the importance of building an interdisciplinary and "robot-proof" education – one capable of navigating the transformations occurring in schools through both the opportunities and challenges posed by AI in teaching and learning.

Lastly, navigating this terrain of complexity, practical challenges, and ethical dilemmas is the interview with Prof. David J. Gunkel – philosopher of technology and leading voice in the ethics of machines. Gunkel offers a profound philosophical reflection on artificial intelligence and social robots, inviting us to move beyond traditional Western dichotomies such as subject/object or anthropomorphism/technological determinism. He highlights the urgency of an interdisciplinary dialogue between engineering and the social sciences, inspired by Platonic dialogue, to critically address the ethical and social implications of 21st-century AI. However, Gunkel warns that such a dialogue risks remaining incomplete and narrow unless it actively engages with "non-Western" traditions of thought, in order to overcome entrenched ethnocentrism and the threat of intellectual colonialism. Drawing on Derridean deconstruction, Gunkel invites us to revisit the ontological distinction between persons and things – especially in an era marked by environmental crises and inequalities. He also proposes a new legal and moral paradigm that recognizes limited forms of "robot rights" – already present in some regulatory frameworks – not to anthropomorphize machines, but to responsibly govern their growing social presence. Finally, from an educational perspective, he advocates for an open and critical pedagogical approach that encourages students to question the very assumptions (and inherited conceptual categories) through which we engage with emerging technologies – revealing how the way we frame a problem may itself be the greatest obstacle to its resolution.

Bibliografia

AlSagri H. S., & Sohail S. S. (2024). Evaluating the role of Artificial Intelligence in sustainable development goals with an emphasis on "quality education". *Discover Sustainability*, 5(1), 458, 1-26. https://doi.org/10.1007/s43621-024-00682-9

Anders G. (1956). *Die Antiquiertheit des Menschen. Band I: Über die Seele im Zeitalter der zweiten industriellen Revolution*. München: C.H. Beck Verlag.

Bakare-Fatungase O. D., Adejuwon F. E., Idowu-Davies T. (2024). *Integrating Artificial Intelligence in Education for Sustainable Development*. In Nguyen, T. V., & Vo, N. (Eds.), *Using Traditional Design Methods to Enhance AI-Driven Decision Making*, IGI Global, 231-245. https://doi.org/10.4018/979-8-3693-0639-0.ch010

Coeckelbergh M., Gunkel D.J. (2025). *Communicative AI: A Critical Introduction to Large Language Models*, Cambridge: Polity Press.

Di Matteo G, Zuccarelli E. (2024), *Intelligenza artificiale. Come usarla a favore dell'umanità*, Milano, Mondadori.

Doshi, R., Dadhich, M., Poddar, S., Hiran, K. K. (Eds.) (2024). *Integrating generative AI in education to achieve sustainable development goals*. IGI global.

Fitas R. (2025). Inclusive Education with AI: Supporting Special Needs and Tackling Language Barriers. *arXiv preprint*. https://arxiv.org/html/2504.14120v1

Hajj-Hassan M., Chaker R., Cederqvist A. M. (2024). Environmental education: A systematic review on the use of digital tools for fostering sustainability awareness. *Sustainability*, 16(9), 3733, 1-25. https://doi.org/10.3390/su16093733

Hasas A., Hakimi M., Shahidzay A. K., Fazil A. W. (2024). AI for social good: Leveraging artificial intelligence for community development. *Journal of Community Service and Society Empowerment*, *2*(02), 196-210. https://doi.org/10.59653/jcsse.v2i02.592

Kukutai T. (2024). How Indigenous communities in New Zealand are protecting their data. *Science*, 384(6691), eado9298. https://doi.org/10.1126/science.ado9298

Maslej N., Fattorini L., Perrault R., Gil Y., Parli V., Kariuki N., . . . & Oak, S. (2025). *The AI index 2025 annual report.* AI Index Steering Committee, Stanford Institute for Human-Centered Artificial Intelligence.

Nyhan M, & Cryan J. F. (2023). Embed Impact on the SDGs in Research Assessments. *Nature*, 621(258). https://www.nature.com/articles/d41586-023-02860-7

Paglieri F. (2025). *L'intelligenza artificiale: rischi, opportunità, scelte*, il Mulino, 74(1), 192-202.

Palmieri S., Brignone S., Bano L., Antonello G., Grimaldi R. (2023). Robots for Biodiversity Protection: an Educational Classroom Project. *INTED2023 Proceedings, 17th International Technology, Education and Development Conference*, Valencia, 6th - 8th March 2023, pp. 3.452-3.459. https://library.iated.org/publications/INTED2023/start/50.

Pasquinelli M. (2025). *Nell'occhio dell'algoritmo. Storia e critica dell'intelligenza artificiale*. Roma: Carocci.

Preeti N. V. (2025). Artificial Intelligence for social good. Application in Healthcare, Education and Environmental Sustainability. *International Journal for Multidisciplinary Research (IJFMR)*, 7(2), 1-6. https://doi.org/10.36948/ijfmr.2025.v07i02.39029

Rane N. (2023). Roles and challenges of ChatGPT and similar generative artificial intelligence for achieving the sustainable development goals (SDGs), *SSRN*. http://dx.doi.org/10.2139/ssrn.4603244

Razzante R. (2024). *Il governo dell'intelligenza artificiale. Gestione dei rischi e innovazione responsabile*, Bari: Cacucci.

Rodotà S. (2012). Intervento al convegno "Etica, Bioetica, Cittadinanza", Università di Napoli Federico II.

Rodotà S., & Konder C. N. (2021). Tecnoscienza e interventi sul corpo umano. *Revista Brasileira de Direito Civil, 27*, 113–144.

Sachyani D., & Gal A. (2025). Artificial Intelligence Tools in Environmental Education: Facilitating Creative Learning about Complex Interaction in nature. *European Journal of Educational Research*, *14*(2), 395-413. https://doi.org/10.12973/eu-jer.14.2.395

Shireesha M., & Jeevan J. (2024). The Role of Artificial Intelligence in Personalized Learning: A Pathway to Inclusive Education. *Library Progress International*, 44(3), 1-9. https://doi.org/10.48165/bapas.2024.44.2.1

Sissa G. (2024). Le emissioni segrete. L'impatto ambientale dell'universo digitale, Bologna: il Mulino.

UN (2023). *The Sustainable Development Goals Report 2023: Special Edition, Towards a Rescue Plan for People and Planet*, 1-80. https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023.pdf

UN (2021). *Beyond Opportunism. The UN development System's Response to the Triple Planetary Crisis*.

UN (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*. https://sdgs.un.org/2030agenda

Velempini K. (2025). Assessing the role of environmental education practices towards the attainment of the 2030 sustainable development goals. *Sustainability*, 17(5). https://doi.org/10.3390/su17052043

UNESCO (2024), *Innovative Technologies for Inclusive Education: A Review of Best Practices from Global Resource Centers*. https://iite.unesco.org/publications/technologies-for-inclusive-education-a-review-of-best-practices

Schwarz E. (2019). Günther Anders in Silicon Valley: Artificial intelligence and moral atrophy. *Thesis Eleven, 153*(1), 94–112.