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The environmental impact of the digital universe and the role of education

L'impatto ambientale dell'universo digitale e il ruolo dell'educazione

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ABSTRACT The environmental impact of the digital universe is one of the critical challenges humanity faces today. This impact manifests primarily through two forms of emissions: *embedded emissions*, resulting from the processes involved in transporting, processing, and assembling over seventy components, and *operational emissions*, generated by the active use of digital services, such as sending messages or sharing content. This paper examines the educational potential of an emerging discipline named *environmental education of digital resources*. Rooted in a philosophy of education articulated in the final section, this discipline is proposed as a central tool for dissemination and knowledge production within the context of cloud computing. The paper concludes with reflections on the limitations of this contribution and suggests a trajectory toward a new *paideia*, aiming to regenerate thought and redefine our relationship with the digital realm.

KEYWORDS Digital; Environmental Impact; Emissions; Philosophy of Education; Relation.

SOMMARIO L'impatto ambientale del digitale rappresenta una sfida cruciale per l'umanità, articolandosi principalmente in due forme di emissioni: quelle incorporate, derivanti dai processi di trasporto, lavorazione e assemblaggio di oltre settanta componenti, e quelle operative, generate dall'utilizzo attivo dei servizi digitali, come l'invio di messaggi o la condivisione di contenuti. Questo contributo analizza il potenziale educativo di una disciplina emergente, definita "educazione ambientale delle risorse digitali", fondata su una filosofia dell'educazione descritta nell'ultima parte del testo. Tale educazione si propone come strumento centrale per la divulgazione e la costruzione di conoscenze nel contesto del *Cloud computing*. Concludiamo con alcune riflessioni sui limiti del lavoro e sulla necessità di sviluppare una nuova *paideia*, capace di orientare verso una rigenerazione del pensiero e nuove modalità di relazione con l'universo digitale.

PAROLE CHIAVE Digitale; Impatto Ambientale; Emissioni; Filosofia dell'Educazione; Relazione.

1. Introduction to the problem

The issue of the environmental impact of the digital universe (Sissa, 2024) has gained prominence in recent years compared to previous decades. This does not imply that the issue was non-existent or irrelevant in the past; on the contrary, it was already present. However, the attention of policymakers, economists, media, and citizens was not sufficiently focused on it. During the last three decades of the 20th century, public interest on environmental issues was largely directed toward the chemical industry and several significant post-World War II events, such as the banning of the dangerous pesticide DDT in 1972, the toxic cloud in Seveso in 1976, the Bhopal disaster in India in 1984, and the partial explosion at the Chernobyl nuclear power plant.

In the early 1990s, the IT sector, particularly the Internet, experienced rapid acceleration with the advent of the World Wide Web, spearheaded by Tim Berners-Lee. From that point onward, the digital revolution assumed an increasingly global dimension, engaging a growing number of disciplines. Nonetheless, despite the enthusiasm for innovation and its rapid development, discussions surrounding the environmental impact of the seemingly intangible web remained absent. Yet, even then – dating back to the very inception of the internet – it was well understood that its operation required physical infrastructures: cables, circuits, powerful computers, memory systems, and various equipment. These all had to be produced, transported, powered, and, within an increasingly short timeframe, disposed of (Sissa, 2024).

With the dawn of the new millennium, climate change began to draw public attention, particularly with the Kyoto Protocol in 2005. During this period, however, only a few researchers explicitly addressed the environmental impact of the digital universe; the broader context was not yet conducive to its full consideration. In the 2010s, the digital revolution underwent further transformation with the rise of major telecommunications operators and leading ICT multinationals (Wu, 2023), collectively known by the acronym GAFAM (Google, Amazon, Facebook, Apple, Microsoft), later referred to as the Big 5 (Google, Amazon, Apple, Meta, Microsoft). In this context, the 2015 Paris Agreement on climate change was adopted, establishing a roadmap for emissions reductions (UNCCC, 2016).

Since then, studies on carbon footprints have intensified to identify their causes, quantify their impact, and develop reduction strategies. States are now required to account for their carbon emissions through periodic reports – a responsibility increasingly shared by corporations as well (Freitag et al., 2021).

Currently, an annual increase in human presence on the web has been observed, accompanied by growing engagement in new activities and the use of social platforms. As early as 2007, some authors, notably Edward Castronova, referred to the 21st century as the era of the great mass migration to the digital universe (2007). However, the miniaturization of personal devices, the invisibility of digital operations, and users' lack of awareness regarding the infrastructure underlying cloud computing – such as data centers and the entire chain supporting their operation (Pitron & Jacobsohn, 2023) – remain underexplored issues among the general public.

Unlike in previous decades, scientific research has progressively unveiled a range of data concerning the environmental impact of digital technologies. These analyses have addressed the use of personal devices as well as the implications of telecommunication infrastructures and large data centers (Lucivero, 2020; Pitron, 2022; Luccioni, Jernite & Strubell, 2023).

As highlighted in the scientific literature currently available, these data remain partial, difficult to access, and subject to rapid changes. Such fluctuations arise from the evolving patterns of digital technology usage, the energy sources powering the digital infrastructure, and corporate decisions – particularly those of ICT multinationals – regarding their role in the sector (Sissa, 2024). Despite these limitations, the data available call for a broader reflection that also involves the humanities. These disciplines are tasked with foregrounding the issue of the environmental impact of digital technologies, fostering practices aimed at raising awareness of the problem and building a new relationship between humans and machines. This relationship must necessarily account for interspecies conviviality and the sustainability of this dynamic (Pouydebat, 2021; Becker, 2023).

The second section of this contribution delves into the meaning of the two primary sources of emissions in the digital universe: embedded emissions and operational emissions, distinguishing the moments and phases in which each comes into play. The third section, on the other hand, explores the role of education, presenting and juxtaposing some of the leading theoretical perspectives on the subject. These perspectives aim to directly influence daily educational practices, offering a new interpretive framework for analysing the relationship between humans and machines. This approach seeks to promote an awareness that is less artificial and more mineral, less invisible and more tangible, in relation to personal digital devices.

The contribution concludes with a series of final reflections that highlight the various stages of the journey undertaken, while also indicating some constructive pathways for addressing the topic as a challenge oriented toward sustainability.

2. Embodied emissions, operational emissions

The definition of sustainable development formulated by the Brundtland Commission in 1987, established by the United Nations and chaired by Gro Harlem Brundtland, describes sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own. This concept emphasizes the principles of intergenerational equity, highlighting the importance of treating the planet as a borrowed resource that must be preserved through responsible management of its assets.

In relation to the above mentioned definition of sustainable development, embodied and operational emissions can be introduced taking into consideration:

- Environmental/ecological externalities: demand for electricity and water for the proper functioning of technologies such as data centres, streaming content, generative artificial intelligence and related carbon footprints. The life cycle of technological tools and increases in demand for goods and services available "in one click". On the other hand, digital technologies allow greater efficiency in the organization and delivery of goods and services;
- Externalities at economic level: reduction of time and costs of operations of repetitive nature and/or manual and simultaneous decrease in the dynamics of exploitation of disadvantaged geographical areas. At the same time, such automations certainly lead to a loss of jobs from the more mechanical ones up to specialized ones;
- Externalities at the social level, certainly one of the themes here is access to digital technologies meant as access in itself, capacity for use – digital divide, and benefits or results that arise from the use of technologies.

Every product and service is associated with emissions generated throughout its lifecycle, which can be divided into two main categories: embedded emissions and operational emissions. Embedded emissions include those linked to the use of primary energy during production, transportation, and

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disposal processes, while operational emissions stem from energy consumption during the usage phase. In essence, the former pertains to pre- or post-use stages of the product, whereas the latter concerns energy consumption during its use (Sissa, 2024).

Primary energy is defined as any form of energy present in nature that has not undergone artificial transformation. It can be classified as non-renewable (such as coal or oil) or renewable (such as solar or wind energy). Secondary energy, by contrast, results from the conversion of primary energy, with electricity being a typical example, derived from both renewable and non-renewable sources of primary energy.

Embedded emissions represent the total primary energy consumed in the production and disposal of a product, regardless of its actual usage. This calculation considers energy consumed at every stage, from the extraction of raw materials to their transport to processing sites, from production and assembly to the final product. Additionally, reverse processes, such as disassembly, deconstruction, recycling, and final disposal, are included.

The environmental impact of a digital device begins with the extraction of raw materials, progressively increasing along the production chain. This process extends geographically and technologically, involving laboratories, factories, and intercontinental transport. Raw material extraction demands substantial primary energy consumption, which is further compounded by the significant energy required for component manufacturing. These components are subsequently transported to assembly sites, where they form the final digital devices. The overall logistics, including the transportation of production materials, assembled components, finished products, and waste for disposal, further contributes to energy consumption (Berreby, 2024).

Devices such as computers, laptops, and smartphones are complex systems composed of numerous components: batteries, displays, touchscreens, casings, microphones, speakers, cameras, and sensors. They also incorporate advanced technological elements such as central processing units (CPUs), graphics processing units (GPUs), network and wireless processors, voltage regulators, memory systems, and machine learning units. The creation and operation of these devices require approximately 70 chemical elements from the periodic table, which comprises 83 elements excluding radioactive ones.

The functional core of every digital device is the microchip, integrated circuits designed to handle digital information processing and memory. These microchips represent the technological heart of modern electronic devices.

> Microchips and many other high-tech goods are forms of highly organized matter. Since they are manufactured using raw materials with relatively high "entropy" – the natural disorder toward which matter tends – it is natural to expect that a substantial investment of energy and processing materials is necessary for their transformation into an organized form. The embodied and operational emissions are defined (...) for each product or unit of service. The more complex and technologically advanced a product is, the higher the percentage of embodied emissions relative to the total (Sissa, 2024, pp. 42-43, the translation is provided by the authors).

Operational emissions refer to the energy consumption generated during the active use of a device by a user to access a service via an application. Common examples include online shopping, posting on social media, sending messages via WhatsApp, accessing banking services, streaming TV series, conducting Google searches, or interacting with language models. These services, delivered via the internet, involve the processing of user requests by specific computers located in data centers, which generate the corresponding responses (International Energy Agency, 2023; Roundy, 2023).

Although many household digital devices, such as smartphones, tablets, and laptops, have relatively low direct electricity consumption (excluding high-energy appliances like refrigerators), they are almost always connected to the internet. This constant connectivity necessitates the continuous operation of data networks, resulting in additional energy consumption that is often imperceptible to the user (Andreu, Delgado & Torrubia Torralba, 2022; Pasqualetti, 2024).

This energy consumption encompasses not only the power required to operate personal devices but also the energy needed to keep data centers, network infrastructures, and equipment supporting data transmission functional. This "invisible" contribution to operational emissions constitutes a significant component of the overall environmental impact of digital services. «When we are connected to the Internet, every digital activity corresponds to a service request, which in turn requires processing performed elsewhere. In addition to the end digital devices, the Internet and data centers – where the digital services we use through our devices are created and managed – also require electrical energy. These electricity consumptions are neither known nor visible to the end user» (Sissa, 2024, p. 50, the translation is provided by the authors).

Considering concrete examples, the creation of a post containing a photograph involves the transfer of data over the internet from the user's device to the server managing the account. This process encompasses several operations: uploading the image, processing the request by the service, assigning viewing permissions (e.g., restricted to friends or public), and storing the file in the user's allocated space.

The request generated by the digital device travels through the network to the server hosting the service. There, the request is processed, and the result – the publication of the post with the desired parameters – is sent back via the internet to the user's device and to others authorized to view it. Each step of this process, from transmission to the server, to processing, and to delivering the response, contributes to energy consumption and the operational emissions associated with the digital service (International Energy Agency, 2023). «When devices are connected to the Internet, every service request involves transmitting data, generating traffic, and requiring processing: all of which consume electrical energy and thus cause carbon emissions» (Sissa, 2024, p. 47, the translation is provided by the authors).

Finally, regarding the operational maintenance of data centers, it is crucial to highlight the role of freshwater in cooling systems for these processing hubs. As Pengfei Li, Jianyi Yang, Mohammad A. Islam, and Shaolei Ren (2023) note, technology companies provide limited information about the environmental impact of their digital technologies, particularly their AI systems. Based on data concerning the water needs for cooling Microsoft systems, this research group estimates that a person asking 10–15 questions to GPT-3 consumes approximately half a liter of water (Berreby, 2024). This figure, however, varies by region and could be higher for digital technologies requiring more computing power and larger artificial intelligence models. In 2022, Google's data centers consumed nearly 20 billion liters of water for cooling – an increase of 20% from the previous year – while Microsoft reported a 34% increase over the same period (Li et al., 2023).

As Berreby (2024) observes, generative artificial intelligence demands vast amounts of energy for computation and data storage, as well as millions of liters of water to cool equipment in data centers. Regulatory and oversight authorities in the United States and the European Union are beginning to demand greater transparency. Meanwhile, technology companies integrating AI across fields – from writing and surgery to climate modelling – emphasize the potential for artificial intelligence to reduce humanity's ecological footprint. However, increasing calls for clarity, particularly from environmental activists, highlight the concern that promised or achieved benefits may be overshadowed by growing negative effects.

The lack of standards and regulations complicates the collection of accurate data. Estimates indicate that data center cooling consumes potable water, and nearby communities face challenges in monitoring these practices (Li et al., 2023). For instance, in Oregon, where Google operates three data centers, a lawsuit was filed to prevent the disclosure of water usage, creating tensions with local farmers and communities. Similar issues have arisen in Chile and Uruguay, where data center projects have been contested for their impact on local water resources.

A cultural shift is needed in the development of digital technologies and artificial intelligence. In this context, the humanities, particularly education, should play a more active role in raising awareness of the issue and fostering a broader understanding of when and how these technologies should be deployed to serve humanity. This approach must align with a planetary context where all living and non-living entities actively interact.

3. What is the role of education?

This new objective integrates into the field of environmental education but is characterized by a transdisciplinary approach that weaves together the sociology of knowledge, critical pedagogy, and the philosophy of education. From this perspective, it proposes an "environmental education of digital resources", a concept emphasizing the need to manage our relationship with digital resources following principles of external and internal sustainability.

The term *external sustainability* refers to the conscious and respectful use of digital devices, aimed at minimizing environmental impact and preserving life habitats – both human and non-human (Pouydebat, 2021; Ceruti & Bellusci, 2023). In line with the thinking of Ceruti and Bellusci, this perspective calls for a move beyond anthropocentrism, acknowledging that ecological and digital crises can no longer be addressed solely in terms of human survival. Instead, external sustainability points to the Earth as a complex and interdependent system, where all forms of life are entangled in a dynamic web of relationships.

This conception strongly resonates with Bruno Latour's *Actor-Network Theory* (2022), which posits that the actors shaping our world – whether human, animal, plant, technological, or geological – are all active participants in the construction of earthly dynamics. Latour challenges rigid hierarchies between subjects and objects, emphasizing that each element within the network holds agency and contributes to reciprocal influences across the system. From this viewpoint, sustainability is no longer a unilateral human project imposed upon the world, but rather a co-constructed process in which the living and the non-living constantly interact, shaping ecological, cultural, and technological equilibriums.

To adopt a genuinely sustainable outlook, then, means recognizing and respecting this intricate network of interdependencies, and developing an ethics of care that extends beyond the human to encompass the entire fabric of the living and the non-living.

Internal sustainability, on the other hand, refers to an approach to education that goes beyond the mere acquisition of skills, emphasizing self-exploration and attention to "technologies of the self". These are internal tools that can guide patterns of reflection and action. This concept closely resonates with Gert Biesta's notions of *agency* and *transaction* (2014a; 2014b; Priestley et al., 2015) within the philosophy of education.

For Biesta, *agency* is not simply the capacity to make autonomous choices, but rather the ability of individuals to act meaningfully within educational and social contexts. Education, in this view, should support the emergence of the subject as the author of their own actions, rather than reducing them to passive recipients of knowledge. The concept of *transaction*, on the other hand, highlights the relational and situated nature of learning: not as a mere transfer of knowledge, but as a dynamic process involving interaction between the individual and their environment.

Within this framework, internal sustainability can be understood as a space where education fosters conscious and reflective action, encouraging the development of the subject in relation to the self, to others, and to the world.

In a context defined by unprecedented technological and social acceleration (Rosa, 2015; 2023) and driven by automated and alienating flows (Hannerz, 1998; Appadurai, 1996; Stiegler, 2024), the pursuit of staying updated with continuous innovations proves unrealistic. The pace of innovation is too rapid for full assimilation. Therefore, it becomes crucial to invest in the development and maintenance of reflective and actionable patterns that function as timeless structures (Bertin, 1977). These are meta-historical frameworks capable of providing critical anchorage in the face of change. The legacy of established models for problem management must be regarded as reserves of discarded options and opportunities, always available for "reuse" in an exaptive sense (Jullien, 2021; Rossi, Borghini, 2024; Gallese, Morelli, 2024).

To introduce what we define as the "environmental education of digital resources", it is necessary to clarify that its primary goal is to disseminate knowledge about the environmental and digital dynamics outlined in previous sections. However, its scope extends beyond these themes to include issues such as electronic waste (e-waste) management and data colonialism. While relevant, these topics fall outside the focus of this contribution for reasons of thematic coherence.

The implementation of such education demands an approach that transcends mere content transmission, a method critiqued in numerous national and international studies. Instead, we propose a philosophical perspective on education, one that is not an alternative to practice or theoretical abstraction but rather a theory directly influencing the relationship between body, force, and action (Edwards, 2012; Barone et al., 2024).

In this framework, theory becomes a care for thought and a reflection on patterns of action and reflectivity. Gert J.J. Biesta's philosophy of education (2022) is particularly suited to providing a generative theoretical framework, one capable of guiding educational approaches to managing the environmental impact of digital resource use and digital participation. Biesta's framework offers guiding meanings useful for directing future empirical research, laying a solid theoretical foundation to address the challenges of this field.

Before delving deeper into this theory and explaining its selection, it is worth questioning why a transmissive approach falls short. A brief excursus, enriched by a literary metaphor, may prove indispensable to further support the adoption of such a perspective.

There is a significant difference between a genuine cognitive process and the mere retention of informational content. Storing information does not necessarily imply cognitive internalization, as true understanding, processing, and recall involve not only intellectual acts but also the engagement of the entire realm of sensitivity. Sensitivity plays a vital role in attributing meaning, a semantic operation requiring extensive participation that encompasses subjective sensibilities and interpersonal dynamics, making the information itself more meaningful. While utilitarian, fact-based learning connected to specialized, situated functioning exists, it is not the focus of this discussion.

A literary example can help elucidate what it means to retain information without truly "feeling" it – without understanding it intrinsically and in its broader context. Every cognitive process gains meaning only in correlation with a socialized world of meanings, as revealed through language (Wittgenstein, 2009).

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The example comes from *Ficciones* (1986) by Jorge Luis Borges. In the story *Funes, the Memorious* (*Funes el memorioso*), first published on June 7, 1942, in the Argentine newspaper *La Nación*, Ireneo Funes, a farmer, suffers a traumatic brain injury after a fall. This incident changes his memory, granting him the extraordinary ability to remember everything: «*All the branches and clusters of a pergola, the shape of the southern clouds at dawn on April 30, 1882, the trail of foam that an oar lifted from the Rio Negro on the eve of the Quebracho expedition*» (Borges, 1986, p. 25, the translation is provided by the authors).

As Giuseppe O. Longo (2018) observes, Funes is doomed to remember everything without feeling anything. He accumulates details without the systemic thinking or filtering mechanisms that allow one to discern what is worth preserving and what is not, what is crucial to remember for the future and what is not. Consequently, Funes is maladapted, unable to comprehend the internal and external events of his life: he is condemned to recite information.

He has lost the social function of memory and the sense of preserving it in a narrative that works for himself and others (the world).

In our contemporary context, accumulating cutting-edge information is entirely insufficient for several reasons. The rapid obsolescence of knowledge, cyclical changes in labor markets and professions, and the uncertainty about the future triggered by the pandemic have foregrounded the challenge of this decade: cultivating resources in students that can act as safeguards for facing both predictable and unpredictable scenarios. Creative, individual, and collective exploration of problem-solving hypotheses is needed.

We must, ultimately, "reconstruct" the value of formal environments like classrooms, reimagining them not as mere spaces for passive listening and information intake over a schedule-dictated timeframe. Instead, classrooms should be envisioned and lived as places where the future is already taking shape, where individual reflections are active actions that stimulate and structure credible alternative futures (Orsenigo & Valentini, 2024). They should become spaces where care for thought is practiced, and reciprocity in attention and support is cultivated.

This care extends beyond the immediate educational context, projecting into and influencing broader life domains.

In this sense, the present proposal aligns with studies on educational materiality, which, starting with the work of Riccardo Massa, consider teachers, students, educational materials, technologies, physical spaces, objects, artifacts, time, and rhythms as co-authorial nodes in a network that actively participates in the educational experience's realization.

> Human and non-human actors relate to each other, "associate," forming a set of dynamic networks that in turn produce effects. For example, a teacher using interactive technology in the classroom – think of a smart board or a projector – is not just a user of the technology but becomes part of a network where the technology, students, and other human and non-human actors (cables, internet connection, digital skills, bandwidth capacity, arrangement of bodies in space, technical support, blackout curtains, remote control device, subjects taught, etc.) mutually influence the learning dynamics. The heterogeneous actors, aggregates, or assemblages that make up socio-material networks also contribute to the construction of meanings, emotions, moral orders, and power (Barone et al., 2024, p. 78, the translation is provided by the authors).

This represents, therefore, a rethinking of the "materiality of the educational universe".

The issue of technological mediation – namely, the use of material resources as a "third educator" – was already foregrounded in the *Reggio Emilia Approach*, beginning with the reflections of Loris

Malaguzzi. However, this notion had already assumed an essential role in early childhood education through the work of Maria Montessori.

Today, it takes on renewed significance in light of Tim Ingold's *ecology of culture* (2001). In his work, Ingold intersects with the thoughts of Massa and Barone, questioning the taken-for-granted relationship between thinking and doing, between abstract concepts and physical objects. He reminds us that materials "think" within us and that we think through them. This is an ongoing effort, characterized by imbalances and subsequent attempts at rebalancing, to establish relationships among things, objects, the organization of space and materials, and actions guided by abstract intentions.

Central to this discourse is a distinction made by Ingold himself between the concepts of *building* and *dwelling*, describing the transition from the *Building Perspective* to the *Dwelling Perspective*. «From the perspective of dwelling, it is precisely the very act of being in a space that makes it possible to build it. To dwell is not only to occupy a space but means to feel at home, to appropriate it» (Barone et al., 2024, p. 122, the translation is provided by the authors).

In the educational context, fostering the appropriation of space clearly involves negotiating meanings and trajectories of sense. To some extent, it entails repeatedly adjusting the "fusion of horizons", collectively seeking and re-seeking new connections of ideas, meanings, and interpretations, while knowing and recognizing, composing and recomposing the educational space.

This space, on the one hand, consists of networks of matter; on the other hand, it comprises "other matters", such as ideas, documents, rules, and norms. Gert J.J. Biesta's philosophy of education does not propose ideas merely to reflect upon but rather *ideas to think with* (2022, pp. 4-5). For Biesta, to exist as subjects means to be in a continuous "state of dialogue", where the production of subjectivity does not arise internally – from intentions or desires – but is deeply connected to the ways in which one relates to and is called into engagement by the aforementioned materials and "other matters".

Furthermore, Biesta asserts, «the educational task consists in igniting in another human being the desire to exist in and with the world in an adult way, that is, as a subject» (2022, p. 15, the translation is provided by the authors).

In a world marked by automated flows, visible and invisible environmental impacts, and educational spaces whose configurations shift with each passing decade, what does it mean to want to exist in an adult way?

> What distinguishes an adult way of existing from a non-adult one is that in the first case, one is able to recognize the otherness and integrity of that which and who is other than oneself, while in the second case, the otherness is not even considered. In other words, an adult subject recognizes that the world "out there" is truly "out there" and is neither a world we have constructed ourselves nor simply a world at our disposal, of which we can freely do whatever we want. The term "World" here refers both to the natural world and the social world, both to the world of things and to the world of living beings. It refers both to our planet and everything that exists on it, as well as to the other human beings we encounter. It refers, with an interesting term proposed by Alphonso Lingis, both to planet Earth and to the earthlings who inhabit it. Recognizing the otherness and integrity of this world is not an act of generosity on my part that allows the existence of that which and who is other than me. It is not up to me to decide whether the world exists or not. Rather, it is up to me to decide whether to grant (or not grant) otherness and the integrity of the world a place in my life (Biesta, 2022, p. 16, the translation is provided by the authors).

When teaching addresses and directs itself to the other as a subject, it operates in a radically different manner compared to when it relies on a temporal logic (the concept of teaching as the promotion of development or growth) or as the establishment of specific abilities or competences for a generic "after". Here, Biesta intersects with the thought of Jacques Rancière, particularly in the concept of "dis-

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sensus". This concept should not be understood as the absence of consensus or conflict, but following Rancière (2007; 2022), it should be understood as the irruption of an "incommensurable element" into a state of affairs, in a specific "partition of the sensible". Dissensus is not «The opposition of interests or opinions [but] the production within a determined and sensible world of something that is heterogeneous to it» (Biesta, 2022, p. 109, the translation is provided by the authors).

An environmental education of digital resources, supported by such a philosophy of education, thus distances itself from the idea of learning that is embedded in a relationship of comprehension that centers the self as the transformer of the world into an object for the self. This approach radically limits other forms of existence that are more decentralized between the self and the world, where it is the world that calls the self into question, and not vice versa. Therefore, it also departs from constructivist theories that emphasize the action of constructing meaning and the effect of control; here, however, the builder is not at the center of the world being understood: «From a different perspective, one can instead assume that it is the "reception" that shapes the subject-world relationship» (Biesta, 2022, p. 133, the translation is provided by the authors).

The encounter with the resistances of the world, represented by what opposes the subject's initiatives, is a fundamental experience. It reveals that the world is not merely a projection of our mind or our desires, but has its own integrity and autonomy. An emblematic example is the environmental impact of digital actions, which, as highlighted, operates both visibly and invisibly, amplifying the perception of the world as a force resistant to the subject's interpretations and projects (Ceruti & Bellusci, 2023).

In this context, an education aimed at disseminating such themes creates a breach capable of revealing a sensitive state or condition that permeates experience, while often remaining hidden. This education acts as an opening toward proximate resistances, those that are evident but poorly perceived, stimulating a critical awareness. The object of inquiry, therefore, is dual: on one hand, technologically equipped educational environments, such as classrooms, and on the other, wearable or portable technological devices that have profoundly shaped everyday life for the past decade.

We know the operational potential of these objects – the ability to perform meaningful actions with a simple click – but we less often consider the resistances that they "embody" and "emanate". These resistances, independent of our will, continue to propagate and manifest, especially through the environmental impact of digital technologies, which today must be treated as a super wicked problem. In this sense, to address this complexity, education must take on multiple functions: from an analytical rationality that studies the relationship between a single digital action and its impact, to a reinterpretation of the classroom as a formal space capable of generating future and credible alternative meanings; to an education as a practice of subjectivation, through which subjects perceive themselves as active agents in the construction of the curves of visibility, the curves of enunciation, and the forms of interaction that determine contemporary scenarios (Agamben, 2006; Deleuze, 2007, 2018).

4. Concluding notes: a new paideia

This contribution originated from the urgency to reflect on the contemporary meaning of sustainability, a concept that emphasizes the principles of intergenerational equity, highlighting the importance of considering the planet as a borrowed resource – an idea we have sought to extend to the choices and uses of digital technologies and artificial intelligences. Despite the significant progress established by the Kyoto and Paris agreements, these have not been sufficient to raise awareness among populations about the need for a new balance between technological progress and the safeguarding of our habitat. Today, with automated flows and the interconnection between political, financial, and technological choices, the impact involves not only human beings but also the habitats of other living species. Responsibility has become global, yet the understanding of this complexity remains still insufficiently widespread.

In the second chapter, we focused the attention of the educational world on two main forms of emissions related to the digital: embedded emissions and operational emissions. However, for reasons of consistency and space, we did not delve into the topic of embedded emissions, which would require an extensive analysis of the extraction and production supply chain of materials, intertwining issues of human rights and illegality. Another limitation of this contribution is the insufficient treatment of the cloud computing chain, which would necessitate a detailed study of the CO_2 emissions produced at each stage of the process. Despite these limitations, we believe this reflection can serve as a starting point for future developments, laying the groundwork for an emerging discipline that we have defined as "environmental education of digital resources".

In the third paragraph, we emphasized the need for this discipline to be grounded in a philosophy of education that transcends mere information transmission. Teaching should be conceived as a zone of knowledge, a reception from the world, and a decentralization of the self, where the subject is addressed by the world itself. The classroom must become a laboratory space for co-creating credible futures, through the interaction between students, teachers, and objects, within a collaborative framework that recalls Bruno Latour's Actor-Network Theory (2022). Even objects, indeed, actively participate in the construction of new knowledge, contributing to redefine relationships with the digital and fostering a more balanced use of technologies.

In other words, the educational process must regain its center in a zone governed by relationality, designed to decenter the role often idealistically assigned to subjects, understood as the sole bearers of constructive agency. Devices, incorporated into the relationship, acquire educational value only within a context where the friction provoked by the objective world (both living and non-living) determines the various criteria for assimilation, through which its salience is meaningfully recognized and evokes the beginning of a "questioning". Thus, objects actively participate in every interpretative process.

Therefore, it is a matter of promoting a new paideia, oriented towards the regeneration of thought. This regeneration opposes the tendency of scientific and technical progress to fragment knowledge, risking its entrenchment in automatic and mechanical processes, devoid of genuine critical and creative depth.

> A Paideia that helps to understand that knowing means entering into the movement of things, into the play of constraints and possibilities that generate and transform them [...]. A Paideia consistent with the vision of the cosmo-anthropological relationship in which man is not separable from nature, but recognized as an integral part of a complex process of co-evolution. A Paideia that provides the adequate awareness to conceive science and technology not as "Promethean" tools for merely quantitative progress, but as tools to build an alliance with nature, within nature, and to promote the sustainable and equitable improvement of the human condition. A Paideia that acknowledges that the pursuit of a co-evolutionary relationship with all actors of the world, living and non-living, is the precondition for our very survival and for the possibility of outlining a livable and fertile future. A Paideia that recognizes the indivisibility of human life, to be understood, at the same time, as earthly, biological, psychic, social, cultural, and spiritual. Finally, a Paideia that recognizes both the indivisibility and, at the same time, the plurality of humanity (Ceruti, 2024, the translation is provided by the authors).

In this sense, a new paideia proposes a significant expansion of the concept of relationship, where the focus is no longer solely on the relationship between humans and technological devices, but, in a

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more radical perspective – to use a term from Richard Grusin that Michele Cometa reflects on – the relationship between the human and the non-human, between living and non-living entities, the dense «entanglement of bíos, zoe, and téchne» (2023, p. 35).

In the field of philosophy of education, it is essential to broaden the concept of medium, shifting from the traditional understanding centered on human-made technological artifacts to embracing an ecological vision. This perspective includes «a series of complex devices, both organic and non-organic» (Cometa, 2023, p. 28), recognizing that media are not merely tools but elements that structure and mediate relationships between the living, the non-living, and even the "quasi-living", such as technologies that exhibit a form of agency (Cimatti, Maiello, 2024). This vision allows for the placement of technological and communicative transformations within a broader horizon, one that accounts for deep ecological interactions. Education, in this view, as previously stated, is not a linear process of knowledge transmission but a dialogical and relational experience, where the educator is not simply a transmitter or facilitator but a mediator of meaningful relationships with the world.

5. Authors' contributions

According to CRediT System: Enrico Orsenigo – Conceptualization, Resources, Writing original draft; Cecilia Pellizzari – Writing Review & Editing; Michela Bongiorno – Writing Review & Editing; Maria Valentini – Writing Review & Editing; Lino Rossi – Project Administration, Supervision, Writing Review & Editing.

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