

Biodiversity Education

A world-based and
experiential approach

Edited by
Andrea Galimberti, Monica Guerra,
Letizia Luini, Greta Persico

FrancoAngeli 



Education and the Politics of Beauty

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Education is the expression of a political sensibility capable of transforming the world by engaging with its multiple possibilities. Beauty is understood as an opening onto responsibility—not only theoretical but, above all, expressive—towards those dimensions, both within and beyond the subject, that may still emerge or undergo change, thereby generating transformation without being constrained by ideals of pleasantness, completeness, or standardisation. With the aim of identifying and fostering forms of thought and practice that bear witness to the interdependence of the ethical and aesthetic dimensions, the series welcomes studies and research exploring educational processes, experiences, and phenomena as expressions of a creative and poietic vitality capable of bringing to light the connections between individuals, communities, and contexts. *Education and the Politics of Beauty* traces methodological, hermeneutic, and theoretical-philosophical paths through which educational thought and practice may become increasingly capable of rethinking themselves and of envisioning and designing sensible transformations as horizons for education. The series is addressed to students, educators, teachers, trainers, scholars, professionals working in educational and relational fields, and all those who experience—and seek to offer, to themselves and to others—beauty as a living form of learning.

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Introduction

by *Andrea Galimberti, Monica Guerra, Letizia Luini and Greta Persico*

The National Biodiversity Future Center (NBFC) is Italy's first national research and innovation center dedicated to biodiversity. It brings together and promotes research while making the knowledge and technologies developed by various stakeholders accessible, with the aim of monitoring, preserving, and enhancing the biodiversity of species and habitats found throughout Italy.¹ The Center's first annual report, presented at the National Biodiversity Forum, is titled "Biodiversity Is the Solution,"¹ a statement of intent that becomes immediately clear upon reading the introduction to the text:

In the current context of climate change, habitat loss, and local and global species extinction, it is essential to recognize the crucial role that biodiversity plays in maintaining the Earth's functioning. Biodiversity is an essential resource for humanity and for the health of the ecosystems that underpin the regeneration of environmental resources. Why is biodiversity the solution? Italy is among the Mediterranean countries richest in biodiversity and endemic species. This must be recognized and valued. For our country, the protection and promotion of biodiversity must be considered a priority within the context of sustainable development and opportunities for young people (Various Authors, 2024, p. 8).

This volume, in line with this formulation, is based on two premises: the first is an awareness of the central role played by biodiversity in this era of major transformations. As stated in the first NBFC report, biodiversity ensures the functioning of ecosystems, and its protection can mitigate the effects of climate change – and thus the inequalities and health threats it brings. The importance of biodiversity is such that it has been explicitly mentioned, alongside the environment, in the new wording of Article 9 of the Italian Constitution, which states that: «the Republic [...] protects the

¹ <https://www.nbfc.it/en/first-annual-report-on-biodiversity>.

environment, biodiversity, and ecosystems, also in the interest of future generations. State law regulates the methods and forms of animal protection». The second premise of this volume concerns the recognition of the importance of education in addressing today's sustainability challenges, as stated in the 2030 Agenda, adopted on September 25, 2015, and subsequently confirmed in the European Union's Biodiversity Strategy for 2030 (2020) in relation to achieving the goal of becoming a climate-neutral continent by 2050. These objectives have also been incorporated at the national level through the Charter for Biodiversity Education, presented on May 20, 2022, initiated by the Office of the President of the Republic and supported by the Ministry of Education and the Ministry of Ecological Transition. This document lists eleven general principles and related commitments aimed at promoting a culture and education for biodiversity that engages individuals and communities in a shared effort to increase and disseminate knowledge about biodiversity, as well as increasingly eco-sustainable practices and behaviors. This text intertwines issues related to biodiversity with pedagogical approaches and practices.

The book stems from the work of the BEAT (Biodiversity Education and Awareness Team) research group, affiliated with the "Riccardo-Massa" Department of Human Sciences for Education and engaged on behalf of NBFC in biodiversity education and training initiatives. BEAT focuses on addressing biodiversity through pedagogical languages and practices, with the aim of developing biodiversity education and training initiatives.

The aim of this volume, which features a selection of chapters from two previous volumes published in Italian, is to present the conceptual framework within which an approach – in many respects unprecedented – to education for and about biodiversity is situated, exploring its theoretical foundations and methodological considerations in depth. The first part of the text lays the foundation for educational work on biodiversity that is firmly rooted in findings from an analysis of the existing pedagogical literature on the subject, as well as in the knowledge of the ecological and outdoor education traditions. The second part of the volume gives shape to the methodological proposal that has been drawn upon these premises and following more than two years of experiments conducted nationwide with extremely diverse groups of people – young and old, ranging from three years of age to advanced adulthood. This is a collaborative writing project, just as the research process itself was collective, characterized by an interdisciplinary scope thanks to the collaboration with colleagues from the Department of Biotechnology and Biosciences at the University of Milan-Bicocca.

All contributions can be interpreted as potential roadmaps designed to highlight emerging issues related to a given topic, in support of those who are discovering biodiversity firsthand or those who aim to facilitate that discovery. In some ways, the underlying approach that guided the composition of the various chapters draws on experience gained in the field, which led to the development of a method and practical tools designed to foster a continuous renewal of curiosity about the world of which we are a part – and, thus, to enable readers to connect scientific information with their own questions and lines of inquiry.

The experience gained during the national pilot project shows us, in fact, that an instructional use of specialized knowledge on biodiversity risks (implicitly) encouraging participants to adopt a passive stance focused primarily on “receiving” content that has already been codified and validated. This risk diminishes when those engaged in field exploration – by asking their own questions (their own and/or those of the group with which they are sharing the experience) – begin to outline research that they feel are their own. At that moment, it becomes possible to engage with specialized content to deepen one’s own inquiry, to develop further hypotheses beyond those that could be formulated through prior knowledge and experience, and to foster the co-evolution of diverse forms of knowledge.

It is worth emphasizing this point: the approach proposed here goes beyond the idea that it is important to convey accurate and interesting content about biodiversity in educational settings; rather, it seeks to reconcile this important dimension with the possibility that those participating in the educational experience may feel an aesthetic connection to the biodiversity present in that specific place, at that specific moment, and in light of their own life experiences. To attempt to tackle such a complex challenge, we must strive to combine what is said about living things (which, by its very nature, is at a more abstract, general, and decontextualized level) with the thrill of discovery taking shape in the here and now – that is, with the possibility that what intrigues and attracts will gradually reveal the aesthetic dimension of that connection.

The children were masters at this, posing unusual, unsettling, and counterintuitive questions to the experts – questions that could be addressed in two ways: either by “correcting” their errors and bringing established knowledge back to the forefront, or by “playing” with the interpretive possibilities that opened up, putting the theoretical concept (for example, the morphological structure that determines certain perceptual possibilities and not others) at the service of their own journey of discovery. We are all too familiar with the first approach, as it is widely practiced in educational institutions; the second requires preparation and the ability to listen and

engage in dialogue. This is an important distinction, one that often plays out in subtle communicative and relational dimensions, yet generates a profoundly different educational context. Building on these premises and this shared background, the volume is organized around contributions that help outline certain forms of knowledge and approaches for fostering a meaningful and sensitive encounter with biodiversity.

In Chapter 1, Andrea Galimberti reflects on the need to ground the concept of “outreach” regarding biodiversity in complex epistemological frameworks, thereby moving away from the notion of communication as the mere transmission of information. He characterizes it as a field of experience, exploration, experimentation, and discovery, and extends its semantic scope to a process that defines all living things. In Chapter 2, Monica Guerra focuses on the perspective of place-based education, highlighting its points of continuity with biodiversity education, as well as insights that can contribute to an increasingly experiential and contextual interpretation of the latter. In the third chapter, Francesca Rota provides an overview of biodiversity education within the context of international documents addressing education for sustainability and global citizenship.

In the Chapter 4, Davide Maggioni explores the concept of biodiversity: starting from its definition, he outlines the multiple levels of organization that take shape within it, as well as the various dimensions that can be considered to indicate and describe it (for example, the number of species present in a given habitat or their functional diversity). A complex scenario is outlined in which co-evolution with humans is embedded in delicate balances that can take the form of a mutualistic relationship (ecosystem services) or the degradation of the shared habitat, where the role played by human activity in terms of the release of pollutants and the overexploitation of resources is taking on increasingly irreversible proportions. In this regard, urban biodiversity becomes a laboratory of coexistence of great interest that does not always receive adequate attention. Chapters 5 and 6, by Greta Persico, present a systematic analysis of the literature on biodiversity education – which we interpret and translate as “education for biodiversity”: these two contributions provide an overview of scientific research on the topic over the past ten years (2013-2023), highlighting points of interest and new challenges for educational research.

In the second part of the text, which is methodological in nature, we find a contribution by Andrea Galimberti, who, in Chapter 7, highlights some fundamental issues that contemporary pedagogy faces when it sets out to address the challenges posed by the Anthropocene. In particular, the assumptions regarding how we conceptualize ecology are brought to the forefront in relation to the choices made by the BEAT research group during

the national experiment. In this regard, the text explores in depth the concepts of biosemiosis and ecosemiosis and their utility in structuring experiential fields where communicative activity serves as a dimension that cuts across all living things, and where it is possible to encounter biodiversity not in a Nature “out there,” but in a field of differences and similarities that continually point to its intimacy and distance

In Chapter 8, Monica Guerra presents the methodological approach outlined by the BEAT research group through several categories that shape an educational and didactic approach that is both flexible and rigorous, clarifying the set of considerations that, within an ecological framework, can facilitate meaningful experiences related to the understanding and appreciation of biodiversity. Preceding these categories – which serve as frameworks and catalysts for collaborative research – is a concept of learning.

In Chapter 9, Greta Persico focuses on the value of questions as key tools for initiating lines of research that arise from our relationship with places. This results in an extremely multifaceted range of possible questions, which simultaneously reflects the complexity of the topic of biodiversity and the various ways of thinking and languages available to explore it. The questions – all of them legitimate – are thus intended as entry points for deeper exploration, traces of each individual’s research process that can simultaneously become a shared resource that grows and is nourished by the contributions of everyone involved in the experience. The result is an exercise in interdependence between adult educators and children or young people, which opens the door to dismantling adult-centered logics in favor of a co-research approach.

In Chapters 10 and 11, Letizia Luini offers a reflection on multimodal and dialogic documentation practices and the central role these can play in promoting the participation of children and young people in transformative processes of biodiversity education. Documentation plays a central role in the proposal presented here, demonstrating specifically how the multimodal tool of the notebook – drawing on diverse languages and modes of communication – can be progressively enriched with lines of inquiry, questions and hypotheses formulated by those engaged in exploration, provided that the necessary conditions, including ethical ones, are in place to keep track of their investigations.

Part 1

Theories

In search of aesthetic connections. Interweaving biodiversity, biosemiotics, and pedagogy

by *Andrea Galimberti*

Foreword

Preserving the planet's biodiversity² raises many questions from an educational point of view, which can be summarized in one central query: "How can we educate people to perceive, appreciate, cultivate, and promote biodiversity?" This implies, first of all, the ability to recognize diversity and see value in it, and secondly, the aptitude to extend this propensity to areas that belong to all living beings and not only to humans. This is one of the greatest challenges facing Western thought today, namely the need to overcome the dichotomous split between nature and culture and interpret *bios* as an event that unites and relocates *anthropos* within its own sphere of belonging (Ferrante, Galimberti, and Gambacorti-Passerini, 2022).

On a pedagogical level, such a paradigm shift prompts us to continually question the theoretical perspectives, contexts, settings, methods, and tools that can push for learning oriented towards (bio)diversity. More specifically, it is becoming increasingly clear that there is an urgent need to generate meaningful learning about the anthropogenic impact on ecosystems (Wildemeersch, Håkansson, and Læssøe, 2023), i.e., to trigger a "difference that makes a difference" (Bateson, 1976) capable of reorienting basic assumptions and ways of moving in the world.

This chapter will highlight the need to develop practices and experiences that allow adults and children to have greater contact with biodiversity, also in light of epistemological frameworks oriented towards the connection

² Due to limitations of space, we will not discuss the possible definitions of biodiversity or the debate surrounding interpretations of the concept found in the literature surrounding it, which question its status in relation to multiple fronts: environmental, social, economic, and political (Navarro-Perez and Tidball, 2012).

between multiple differences and focusing, in particular, on the potential of an aesthetic perspective.

The power of diversity: the flourishing of complexity

We have at our disposal traditions of thought which, since the 1950s, have profoundly shaken some of the basic assumptions of Western thought, pushing it in the direction of valuing the diversity of life in all its forms. I am referring, in particular, to the lessons offered by systemic thinking and the epistemology of complexity, which have outlined fundamental conceptual lenses for observing and considering so-called non-linear systems (Galimberti, 2024). These perspectives have identified biodiversity as an essential characteristic of the ecosystems to which we belong, contributing decisively to the emergence of ecological thinking and the first environmental movements (Slack, 2011), inscribing the continuous generation of new morphological characteristics and behaviors in an enrichment of the evolutionary repertoire (Pievani, 2019). Nonlinear systems are characterized by a variety that never occurs in linear systems (Gleick, 1989), and this differentiation allows them to react actively and creatively to contingent and unexpected events, developing a wide range of possible responses to the information circulating in the environment and moving away from rigid automatic reactivity. A system «endowed with variety, redundancy, and flexibility is more stable and less vulnerable to external shocks than a uniform system with little variety and flexibility» (Meadows, 2019, p. 27). Therefore, impoverishing any habitat – from rainforests to neighborhood parks, from the gut microbiome to our genetic makeup – means reducing its self-organizing capabilities and exposing it to risks when the conditions that keep it alive change. At the same time, it should be noted that these are delicate balances: when the parts of a system open up spaces for plural interaction (so-called “loose coupling”), the margins of uncertainty and unpredictability increase, including the risk that relational dynamics will take the system out of the equilibrium it has achieved, towards a new form or destructive path. In this regard, studies on complexity have emphasized how life always arises on the margins of chaos and has a close connection with it: these are contingent, unpredictable processes that are extremely sensitive to a multitude of variations (even minimal ones) and to the continuous dynamic dialogue between constraints and possibilities (Ceruti, 2018). The flourishing of “a thousand beautiful forms” (Carroll, 2011) is always connected to the need to maintain an organization capable of surviving over time:

Organization connects different elements, events, or individuals in an interrelated manner, which consequently become components of a whole. It guarantees solidarity and solidity in relation to these links, and therefore guarantees the system a certain possibility of durability despite random disturbances. Organization therefore: transforms, produces, connects, maintains (Morin, 2001, p. 117).

These reflections on the link between the continuous construction of differences and the need to constantly consider the constraints imposed by every organization, in a turbulent dynamic with outcomes that are never entirely predictable, have not been limited to “natural” phenomena, but have been intertwined with the “cultural” dimension, following a line of continuity between these two domains. Edgar Morin, for example, clearly showed in his theoretical work on method how it is possible to insert human theoretical constructs within an ecosystemic dynamic (Morin, 2004) and, similarly, Gregory Bateson proposed perspectives aimed at creating a “creatural grammar” (Baracchi, 2013) designed to study «the laws of communication in the biosphere» (Bateson and Bateson, 1989, p. 215) and to formulate descriptions that position humans within a broader “ecology of the mind³”. We cannot, of course, summarize the work of these two authors here, but we are interested in proposing them as examples who, along with many others, have insisted on seeking formal similarities in the organizational and communicative structure of all living things: it is thanks to contributions of this kind that it is now possible to interpret and extend descriptions of living things to humans⁴ within the social sciences. This continuity should not be taken for granted and is a strong inspiration for a pedagogy aimed at thematizing and valorizing it.

³ Here is an example of a Batesonian statement that takes a broad ecosystemic approach: «Ideas are interdependent, they interact, they live and die. Ideas that die do so because they do not harmonize with others. It is a sort of complicated, living tangle that struggles and collaborates, similar to what is found in mountain areas, composed of trees, various plants, and the animals that live there – an ecology, in fact» (Bateson, 1997, p. 400).

⁴ This is understood not only from a theoretical perspective, but also in the pragmatic dimension inherent in human organizations. We can see, for example, how the for-profit and non-profit worlds have long been committed to policies aimed at promoting diversity (gender, ethnicity, culture, age, etc.). In addition to considerations of social justice and the need to ensure equal opportunities (issues that can also be exploited through “social washing”), the underlying belief is linked to the idea that diversity management leads to the creation of more complex working groups that can dialogue with the uncertainties and variability of their areas of reference, stimulating creativity, despite the risk of greater misunderstandings and conflict. These ideas are closely linked to evolutionary biology (Ferrante, Galimberti, and Gambacorti-Passerini, 2022).

The risks of the reduction of complexity

The traditions of thought previously mentioned, while contributing to the spreading of certain aspects of an ecosystemic sensibility, have encountered – and continue to encounter – many obstacles to their progress. This resistance helps us consider the reasons why the obvious benefits of (bio)diversity often fail to find fertile ground in terms of creating harmony with “common sense”, thus reminding us of the urgent task of promoting and communicating them. The attempt to assert counterintuitive premises that are often not immediately attributable to everyday experiences and our perceptual constraints (Pievani, 2002) creates a fundamental difficulty that we cannot ignore: for example, the perception of being “part of” an ecosystem of which we observe only “arcs of a larger circuit” (Bateson, 1976) clashes with the division between *res cogitans* and *res extensa*, and therefore with a long-standing rationalist tradition that sees technology as an affirmation of superiority and domination and is antagonistic to heterarchical (Harries-Jones, 2019) and hybrid (Latour, 1995) conceptions of the connection between human and non-human (Ferrante, Galimberti, and Gambacorti-Passerini, 2022). The anthropocentric premise that “elevates” *anthropos* to the measure of all things, assuming its ontological and epistemological primacy without raising critical issues or questions (*Ibid.*), persists despite the evidence of the sad “geological” effects (Chakrabarty, 2021) of our ability to continuously build and transform ecological niches. The study carried out by Ron Milo's research group at the Weizmann Institute of Science in Israel showed us how, in 2020, the “anthropogenic mass”, i.e. the mass of all the materials that *homo sapiens* has produced on earth, exceeded for the first time in human history the total biomass, i.e. the total mass of living organisms⁵ (Elhacham *et al.*, 2020). These data have a great metaphorical impact: human consciousness, this “efflorescence of complexity” (Morin, 2001), continues to distance itself from the nature to which it belongs and is prey to the processes it, itself triggers, thus becoming separated from the contexts it incessantly colonizes.

To this we must add that «complexity is a problem word, not a solution word» (Morin, 2001, p. 2), so it raises questions in terms of dilemmas, aporias, and paradoxes and does not offer a structured method based on ready-made solutions and clarifying visions: the impossibility of

⁵ The mass of anthropogenic origin, which doubles approximately every 20 years, will reach over two teratons by 2040. This means that each person produces an amount equivalent to twice their weight every week. Perhaps the most staggering aspect concerns the historical trend: at the beginning of the 20th century, anthropogenic waste accounted for only 3% of total biomass (Elhacham *et al.*, 2020).

comprehensive knowledge – which marks the end of the dream of omniscience (Ceruti, 2015) – is a constitutive dimension of it. We can only respond to the challenge posed by this paradigmatic revolution with “reductions in complexity” (Luhmann, 2018), that is, by assuming responsibility for the limitations inherent in every point of observation, every practice, and every conception. This is not an easy stance to take because, faced with the chaos and uncertainty that any complex system brings with it, there is a risk of developing a monological way of thinking aimed at separating and dividing in order to absorb differences and organize them into a clear and linear hierarchical order (Harries-Jones, 2019), instrumentally aimed at maximizing one’s own reference variables.

True biological goals always have a limit. One always seeks to have optimal quantities – of oxygen, calcium, proteins, psychotherapy, love, whatever it may be. We think about money as if it were good to maximize its availability, and therefore we might also maximize the availability of oxygen, calcium, proteins, psychotherapy, and so on. Maximizing certain things always makes them toxic. In the authentic biological world, every desirable object becomes toxic beyond a certain limit (Bateson, 1981, p. 354).

This is an instrumental way of thinking that, in its focus on absolute performance, requires a fundamental uniformity that causes the peculiarities of contexts to disappear (as intensive agriculture based on monoculture clearly shows), as well as the dimension of contingency and its ability to trigger unexpected and divergent processes (Pievani, 2016; Huy, 2019). Faced with the mystery of what is “ungovernable”, the desire for control grows (Ronchi and Stiegler, 2019). However, manipulating, changing or “adjusting” the balance of a system instrumentally leads to profoundly anti-ecological attitudes, even if guided by the best of intentions. The perspective of complexity accentuates the impossibility of imposing a unilateral will on non-linear systems: «The idea of making a complex system do exactly what we want can only be achieved, at best, temporarily» (Meadows, 2019, p. 212).

One of the greatest mistakes made to the detriment of human beings by the scientific community, perhaps especially by the engineering community, is the assumption that it is possible to have total control over an interactive system of which one is a part. Now this is one of the major pathologies in family life, in marital relationships, in organizations in general and so on [...] engineering is one of the things responsible for this error in ordinary people [...] but ideas of control errors in general are one of the major sources of social and individual problems (Bateson cited in Deriu, 2000, p. 27).

Faced with reductions in complexity that become “epistemological pathologies”, Bateson had already pointed out in the 1970s the need to move in a different direction, centered on an aesthetic dimension:

We should not allow the imperfection of our understanding to fuel our anxiety and thus increase the need for control. Our studies could rather be inspired by a more timeless motivation, even if today it appears less respectable: curiosity for the world of which we are part. The reward for this work is not power but beauty (Bateson, 1994, p. 32).

But in what sense is the concept of beauty used? How are the valorization of biodiversity and the search for beauty connected?

Biodiversity, biosemiotics and pedagogy

From what has been stated in the previous paragraph – albeit briefly – it becomes clear that in a social, economic, cultural, and epistemological landscape rife with contradictions and tensions, it is not enough to simply communicate the beauty of (bio)diversity. Although disseminating information on issues related to the delicate ecosystemic balances in which we are immersed is a fundamental strategic aspect, it cannot be the only one given the urgent need to bring about far-reaching change (Wildemeersch, Håkansson, and Læssøe, 2022).

An exclusive focus on the transmission of information from experts runs the risk of creating instructive educational settings based on passive reception, conveying pre-formed ideas and values and losing the ability to pose open questions capable of raising the dilemmas, contradictions, and tensions that intertwine with and shape ecological issues. More specifically, the absence of multifaceted exploratory itineraries reduces the possibility of structuring a plural vision of biodiversity, precluding openness to its possible meanings and its multidimensional nature, connected to social, economic, and environmental interactions (Navarro-Perez and Tidball, 2012). Furthermore, there is an increased risk of failing to expose subjects to something capable of opening them up to other experiences (Dewey, 2004), or of failing to offer them a learning context that can become meaningful in light of their own existential journey. In other words, we would fall into the paradox of conveying the complex dimensions implied by biodiversity in a linear and one-dimensional way, structuring an educational process that separates the subject and object of the experience, thus reintroducing the divisions already partially mentioned. To move in a different and complementary direction, following Bateson’s reflections, it may be useful

and interesting to combine “scientific explanation” with the search for an “aesthetic dimension”, which we define as follows. The term “aesthetic dimension” is understood primarily as sensitivity to context, that is, as the ability to perceive⁶ the pattern that connects the subject and the context of the educational proposal. This framework includes innovative research and training activities (Birbes, 2017; Guerra, 2020; Strongoli, 2021; Antonietti *et al.*, 2022; D’Aprile and Bufalino, 2024) committed to “reconnecting people to nature” (Navarro-Perez and Tidball, 2012), developing a “sense of place” (Ardoin, 2006), and developing contingent and local knowledge (Jiménez *et al.*, 2014; Mortari, 2020). Experiences aimed at intercepting and addressing – through exploratory and active involvement – the affective and vital dimensions that are always implicated in the variety of ways in which subjects “incorporate” their contexts of reference (Beery and Jørgensen, 2018).

One of the great lessons of biodiversity consists precisely in showing how every living being takes on characteristics in relation to its own ecological niche and, vice versa, how it is never a static and predefined element, but constantly generated in the encounter, through a circular and recursive interaction (Harries-Jones, 2019). From a pedagogical point of view, this means questioning how to structure settings in which to pose questions and constraints to confront and clash with, putting oneself at stake to explore aspects that are not pre-established, but intertwined with the “web of life” (Capra, 2022) that each of us develops along autobiographical paths (Wiegelmann and Zabel, 2021).

The aesthetic dimension is also understood here in terms of abductive reasoning⁷, based on the idea that there is continuity in the organization of living beings. Underlying this is the concept that nature develops in a “parsimonious” way through recurrences or, as Peirce stated, that nature tends to assume “habits” (Hoffmeyer, 1996) thanks to which it becomes possible to obtain information on the organization of the unitary fabric of living beings themselves: all complex systems, in biology, culture, and society, are characterized by a common similarity (iteration) given by the tendency to develop according to patterns (Wheeler, 2005). The possibility of grasping these forms is at the heart of the idea of beauty celebrated by Bateson. His famous question: «What pattern connects the crab with the

⁶ In the sense of “perceiving with the senses”, following the etymology of the term *aisthesis* (see Borutti, 2006).

⁷ For Peirce, abduction is an immediate and precognitive act that operates along the difference/similarity axis and through which every organism organizes its own information (see Vitti-Rodriguez and Emmeche, 2017). It takes on a typically iconic character, thanks to which living beings intercept common principles behind differences, thus acquiring the ability to classify and categorize.

lobster, the orchid with the primrose, and all four with me? And me with you? [...] What is the structure that connects all living structures?» (Bateson, 1976, p. 73) shows, for example, how bilateral symmetry (the common feature that unites the form of these living beings) developed in conjunction with interactive and communicative processes structured over the course of evolution.

Studies on biosemiotics, which stem precisely from these reflections (Hoffmeyer, 2008), identify in the semiotic fabric the phenomenal continuity that connects the entire bios (Brier, 2008). From this perspective, the environment, the ecological niche, the frame of reference (the *Umwelt*, see von Uexküll, 2015) of any organism is represented by all those elements that it “interprets” (according to Morin, “computes”): in other words, it is generated by the set of acts of semiosis, understood as «modeling systems formed evolutionarily over time»⁸ (Robuschi, 2018, p. 154). In this sense, the evolution of life can be understood “as the history of the emergence of increasing levels of semiotic complexity – or, as Hoffmeyer defined it, “semiotic freedom” (Wheeler, 2005, p. 28). Humans, therefore, are not in stark contrast to nature, but are characterized by a unique relationship with their *Umwelt*, which is also shaped by culture and linguistic acts:

Biosemiotics bases its theory on the idea that life and semiosis are coextensive, where semiosis is not something supernatural or abstract, but rather a natural interface through which every organism actively negotiates and coordinates the demands of its internal organization with the demands of the surrounding organization. The perspective of biosemiotics [...] posits as an essential foundation the extension of semiosis to all living beings, considering them too to be active agents capable of attributing meaning and, consequently, modeling their own *Umwelt*. In other words, the possibility of semiosis here becomes the dividing line between living beings and inanimate objects (Robuschi, 2019, p. 569).

This perspective extends «the zone of semiotic production from the human to the living, from an anthropocentric cultural level to a biocentric level» (Iovino, 2015, p. 105) and allows us to attribute to the aesthetic act, understood as the perception of connections organized into forms (“organized distinctions”, see Ellis, 2006), the possibility of bringing us closer to a common world, or rather to a «complex totality consisting of

⁸ Biosemiotics proposes various fundamental forms of modeling that we share, from an evolutionary point of view – at different levels – with all living beings, such as belonging to a meaningful *Umwelt*, code duality, endosemiotics, and the embodiment of cognitive processes: «Other living beings – in the act of interpreting and giving meaning to their own *Umwelt* – also share, at different levels, the modeling structures typical of aesthetic behavior» (Robuschi, 2019, p. 568).

relational connections to which we have only partial access thanks to interpretative acts of semiosis» (Robuschi, 2019, p. 582).

Such a clearly defined aesthetic dimension can be an interesting source of inspiration for educational experiences aimed at identifying and creating connections between the acts of discovery, interpretation, and perception of the participants and those of the living being to which they relate. In this regard, artistic and performative languages⁹, which operate precisely on the iconic and analogical dimension, have great potential in revealing a profound harmony that we feel is lacking today: they are not so much tools to be used simply for their iconic effectiveness, but rather ways of multiplying the possibilities of the semiotic dimension. In a recent work, Amitav Ghosh (2017) lamented the absence of great narrative and literary imagination on issues related to the ecological emergency and the predominance of non-fiction linked to logocentrism and underlying rationalism. His arguments, which push in the direction of greater support for the use of iconic languages that unite us with all living things, are very much in line with the biosemiotic perspective and raise fundamental questions that can stimulate new creative processes in educational design: «Does thinking about the era of climate change mean thinking in images, moving away from our usual logocentrism?» (Ghosh, 2017, p. 94). In this sense, setting up educational contexts in which it becomes possible to intertwine scientific information with the analogical dimension – along the “double description” that Bateson believed was capable of offering greater depth and coherence in the interpretation of living beings¹⁰ – may represent an interesting and promising avenue for pedagogical experimentation.

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⁹ In biosemiotics, «art, like culture, is nothing more than the product of a meaningful and interpretative approach to our surroundings, i.e., the particular patterns or structures we construct to give meaning to our environment» (Robuschi, 2019, p. 566).

¹⁰ For Bateson, «Every abduction can be seen as a double or multiple description of the same object or event or sequence. If I examine the social organization of an Australian tribe and analyze the pattern of relationships on which totemism is based, I can see that these two sets of knowledge are abductively related, obeying the same rules» (Bateson, quoted in Harries Jones, 1995, p. 177).

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Place-based theories and practices. Topics and issues for ecological and biodiversity education

by *Monica Guerra*

This paper aims to introduce and discuss the perspective generically defined as place-based education, considering it consistent with, as well as relevant to, educational theories and practices focused on environmental issues, particularly in relation to biodiversity. This concept, now pervasive in ecological and environmental discourse despite its recent origin (Wilson, 1988) and whose protection is considered increasingly vital (Katili *et al.*, 2021; Watson *et al.*, 2021), refers to the variety of living organisms and the ecological systems in which they live, but also to their variability (Secretariat of the Convention on Biological Diversity, 2001), suggesting an exponentially extended range of biological diversity. It is precisely this articulation, which is intertwined with a high degree of contextual specificity, that allows us to hypothesize a harmonious relationship with place-based pedagogies, which are by their nature rooted in places and oriented towards the environment.

Place-based education

To begin with, it is useful to note that place-based education is a broad concept. As such, it has been used in complex and diverse ways over time, to the extent that, according to some, it does not seem to have «a specific theoretical tradition, although this is partly a question of nomenclature» (Gruenewald, 2003, p. 3). In this vein,

its practices and aims can be linked to experiential learning, contextual learning, problem-based learning, constructivism, outdoor education, indigenous education, environmental and ecological education, bioregional education, democratic education, multicultural education, community-based education, critical pedagogy

itself, as well as other approaches that address the context and value of learning and nurturing specific places, communities, or regions (*Ibid.*).

We are clearly dealing with what can be defined as an umbrella concept, under which many interpretations and different approaches can be found.

Although the definition in this formulation is more recent, it can nevertheless be agreed that its original meaning has its roots in progressive educational movements – Dewey’s thinking (and, among his texts, *School and Society*, 1899) – which, as early as the first half of the last century, advocated an experiential approach to education and learning based on the environment (Tooth and Renshaw, 2009). From this perspective, there are two original characteristics that remain fundamental to understanding the proposal: the strong emphasis on experiential learning, on the one hand, and the connection with the local and contextual dimension of the environment, the territory, and the community, on the other. These are two characteristics that are by no means neutral, from which interpretations have been derived over time that tend to emphasize one aspect or the other, to the point of overlap that has risked producing real coincidences. This has led to place-based education being at times generalized as a predominantly activating proposal, a risk inherent in activism as a whole, or as a proposal for exclusively environmental education, a possible limitation that is nevertheless an element of interest in this context.

The emergence of literature specifically related to this topic dates back to the 1990s (see the excursus in Beames, 2015) and continues to this day (see, for example, the recent review of the literature on this subject by Yemini, Engel, and Simon, 2023), which has been explored in depth from both a theoretical and methodological perspective with numerous contributions, but which continues to be perceived as an innovative and unconventional approach: the review mentioned above identified around 300 publications in English alone over the last 20 years, half of which relate to school environments (and, again, almost half of which relate to studies conducted in the United States), indicating the vitality and relevance of the construct. At the same time, this review highlighted a recurrence in the references cited in the definition and framework of place-based education, with a predominant reference to the contributions of Sobel, Smith, and Gruenewald, to whom we will consequently refer in particular here as well.

One education, five different approaches

A useful starting point for a summary could be the work proposed by Smith (2002), which aims to explore the state of the art in place-based education in the early 2000s. Smith identifies five approaches emerging from the analysis of practices, particularly teaching and learning practices, which allow for a better understanding of the most relevant dimensions depending on the specific context, while acknowledging, as stated from the outset, that «because place-based education is by its nature specific to particular places, generic curriculum models are not appropriate» (Smith, 2002, p. 587).

The first approach concerns what are known as local cultural studies (*Ibid.*), which are also those with the longest tradition. These generally refer to programs that explore issues or phenomena that are important for a given territory or community by focusing on a major theme around which teaching in each subject area is structured: in this approach, the focus is mainly on cultural or historical dimensions, but with attention to the connection that the themes have with the experience of children and young people, as well as their families. This invitation to give importance to what is familiar, recognizing it as worthy of being addressed, explored, and studied, also appears significant in relation to biodiversity education, which then becomes a pressing issue that directly concerns them, based on their own experience.

The second approach concerns studies on local nature (*Ivi*, p. 588), characterized by fieldwork, which is at the heart of the proposal: in this case, with a movement that can take students outside, but also generate “living” laboratories in the school. The experience develops primarily through direct observation of environments or phenomena and field research, using various tools for data collection, sometimes leading to the restoration of areas if deemed necessary. In this application, as in the previous one, local work is subsequently extended to other territories, even those far away, which nevertheless find new understanding precisely from the primary direct experience in one’s own. This approach, which is particularly interesting in the context of in-depth study of biodiversity education, aims to enhance children’s spontaneous curiosity about the physical world, which is often neglected or ignored by schools, especially when they follow national school curricula that rely on textbooks written for a generic market and that tend «to focus on definitions and general principles rather than on questions drawn from children’s immediate experiences» (*Ibid.*), resulting in distancing them from the real world.

With regard to studies on local nature, it is important to emphasize that it is now known that a fundamental characteristic for supporting the growth of ecological awareness is precisely the possibility of experiencing the

environment continuously, rather than occasionally, so that the world can become a habitual sphere of life and knowledge (Payne and Wattchow, 2008; Judson, 2015, 2017; Guerra, 2020). In addition to this, some of the teachers interviewed by Smith point out that their students «consistently achieve better results compared to their peers in other schools, even without a focus on test preparation, and the school has been remarkably successful in attracting a diverse student population to its program» (*Ivi*, p. 589). The approach in the field referred to here as place-based, similar to other experiences that bring education outdoors, leads not only to greater ecological awareness but also to improved learning (see, for example, Rickinson *et al.*, 2004; Meighan and Rubenstein, 2018; Kuo, Barnes, and Jordan, 2019).

A third approach refers to the investigation and resolution of community problems. This is carried out by going beyond the confines of the classroom (*Ivi*, p. 589): in this perspective, defined as real-world problem solving, students are engaged in identifying issues of interest to them that affect the school or community, exploring their characteristics and dynamics, as well as potential solutions, an aspect of particular interest from the point of view of biodiversity education. Here, students are strongly engaged and involved, while teachers act as facilitators of the process, assisting in field research and connecting it to the topics covered in the curriculum, a curriculum that emerges from the field.

These aspects are further emphasized in the last two approaches proposed by Smith, one relating to internships and local professional opportunities (*Ivi*, p. 590) and the other to integration into community processes (*Ivi*, p. 591). Specifically, the fourth approach seeks to counteract the tendency to leave the place where one grew up after finishing high school, when these places seem to offer no valid professional opportunities. This is accomplished by promoting experiences and reflections on the relationship between vocation and territory and by generating a potential virtuous circle between the skills that are developed and the resources that are injected into the community. The fifth, on the other hand, involves a significant commitment to identifying not only the resources but also the local partners needed to implement the changes deemed necessary, thus completing the intertwining of educational action and its impact on the territory: in fact, students are involved not only in the cultural, social, and economic life of their community, but also in its decision-making processes, in dialogue with public bodies and at the service of the well-being of the community. Through these experiences, youth perceive the value of their contribution, consolidating their relationship with the environment they live in, which is of particular interest for biodiversity education as well.

Within the wide variety of experiences identified in this articulation of approaches, Smith highlights several cross-cutting elements. Alongside a renewed role for both students and educators – the former as proactive investigators of their environments (Nichols *et al.*, 2016), strongly empowered in defining the objects of study and work and in constructing knowledge, but also valued in relation to their environment and community; the latter committed to facilitating processes and connections and to outlining and sharing programs rather than transmitting them, with a role more as partners than supervisors – the centrality of local phenomena, culturally and physically understood, emerges as the foundation of the educational experience. This is also the key to accessing more distant and/or abstract experiences and knowledge relating to other places, together with the growing permeability between school and community, which are mutually engaged and intertwined (Smith, 2022, pp. 593-594). This renewed connection, which brings children back into the natural world, on the one hand, allows each child to recognize the value they have to others, transforming them into young citizens who can fully participate in community processes and thus promoting their sense of agency (James, Jenks, and Prout, 1998; Kallio and Häkli, 2013), as well as allowing communities to benefit from their contribution; on the other hand, it supports an idea of unmediated schooling and education, in which there is strong integration between school subjects and a clear contrast to standardized knowledge (Smith, 2007). This seems to contribute, albeit with a significant investment of time and resources on the part of teachers, to breaking the behavioral and programmatic patterns that have slowed the implementation of meaningful environmental education in schools, bringing together local cultural, environmental, economic, and political issues and encouraging convergence between the social and environmental dimensions (*Ibid.*), all aspects that are consistent and significant in redefining and qualifying education for biodiversity.

Thematizations and orientations from place-based education

At the same time that Smith outlines the prevailing approaches in place-based education, Gruenewald (2003) analyzes place-based pedagogies by relating them to critical pedagogy, with the aim of providing a theoretical framework for what is often considered primarily a methodology (Beames, 2015), and defines them as «necessary for citizen education to have a direct influence on the well-being of the social and ecological places that people

inhabit» (Gruenewald, 2003, p. 3). At the same time, drawing on the literature review by Woodhouse and Knapp (2000) – in which they identify the distinctive features of place-based education as its delineation from the particular characteristics of the place, its intrinsic multidisciplinary and experiential nature, its reflection of a broader educational philosophy of «learning to earn», and its connection of the place with individuals and the community – Gruenewald hypothesizes that the most revolutionary aspect is precisely its origin in the peculiarities of the context (2003, p. 7). This emphasis allows him to highlight another interesting aspect of place-based education, already partly mentioned by Smith, but further emphasized here, namely that it can represent a clear alternative to standardized educational approaches, which generalize experiences and do not embrace the idea of place as a primary experiential context, replacing it with more traditional, as well as general, disciplinary content and ignoring differences between students. According to Gruenewald, however, educators who take a place-based approach «do not ignore the importance of content and skills, but argue that the study of places can help increase student engagement and understanding through multidisciplinary, experiential, and intergenerational learning that is not only relevant but also potentially contributes to the well-being of community life» (*Ibid.*).

Gruenewald's reflection is also of interest for the way it addresses the relationship between the local and the global. This is undoubtedly a sensitive aspect of place-based education and, likely, of biodiversity education as well, since both, in focusing attention on a specific context, carry the risk of narrowing one's perspective, leading to the potential dimming of a broader perspective of the issues at hand.

However, here as in the place-based perspective in general, encountering a real place redefines the relationship with the environment on a local scale, which can only be the starting point for a deeper understanding of issues otherwise perceived as distant and abstract, but also the premise for a more authentic understanding of global issues. After all, the issue of curriculum standardization is one of the aspects that has hindered the implementation of meaningful environmental education, together with the simultaneous lack of experience and knowledge of the places in which teachers themselves operate, leading to the reiteration of an education that is in turn generic and standardized, distant from the contexts and experiences of children and youth (Judson, 2017). In this regard, Gruenewald refers to some of Sobel's earlier contributions, which are considered fundamental references on the subject, in which the author invites us to pay critical attention to “premature abstraction” (Sobel, 1996) with which global crises such as «the extinction of exotic species, the destruction of rainforests, acid rain, and global

warming are usually discussed» (Gruenewald, 2003, p. 7), favoring instead «pedagogical strategies that honor students' predisposition to engage with complex ecological issues» (*Ibid.*). Following an analysis of numerous studies and practices aimed at developing environmental values, Sobel concludes that «the most important thing is that children have the opportunity to connect with the natural world, and learn to love it, before they are asked to heal its wounds» (Sobel, 1996, p. 10). This is consistent with a relational ecological approach, according to which each person's ecological representations and actions are defined through opportunities to encounter and learn about the environment, particularly the natural environment, experienced over time in places that gradually become meaningful and are therefore perceived as more worthy of interest, love, and care (Judson, 2019). In this sense, place-based education appears in stark contrast to educational approaches aimed, on the one hand, solely at providing information and, on the other, at catastrophism, which, moreover, have all shown their limitations in terms of effectiveness (Judson, 2010).

Subsequently, Sobel defined place-based education as a reconceptualization of environmental education, but extended beyond the natural sciences and interpreted in a multidisciplinary key. In *Place-based education: Connecting classrooms & communities* (2004), she outlines some aspects that can characterize a place-based model aimed at promoting a rethinking of the school itself. Starting from the assumption of sustainability as a basic metaphor, Sobel insists on the possibility that this approach offers to move from a conceptual model defined by fragmentation to one based on systemic thinking: through this type of planning, students can experience how sectors of the community such as education, economics, and health are not separate areas, but are all systematically connected to each other (*Ivi*, pp. 27-28).

Furthermore, starting from the here and now, this approach proves capable of connecting with the past and, at the same time, with the future, working towards sustainable development (*Ivi*, pp. 29-31). Furthermore, the tension between the idea of compulsory monoculture and one that identifies diversity as the goal of school contexts is highlighted (*Ivi*, pp. 31-33). In this proposal, the character of the local environment and culture are the prerogatives that should inform the culture of the curriculum itself, again in opposition to compulsory study programs and tests that emphasize assessment, in the belief, evidenced throughout his text and already anticipated here, that a good education based on the local area naturally leads to improved academic results. Yet another aspect identified by Sobel is one oriented towards the creation of social capital, which, as also highlighted by the other authors considered, leads to a greater sense of personal well-being among citizens, which ultimately translates into economic well-being

for their communities, and often – an aspect that is also relevant to biodiversity education – a commitment to preserving the quality of the environment (*Ivi*, pp. 53 and ff.). For all these reasons, Sobel argues that place-based education «converts the activist stance of Not in My Backyard» (NIMBY) to Please in my Backyard (PIMBY) (*Ivi*, p. 12): a shift that places environmental, social, and economic issues in the here and now, in territories and communities, but above all in places of education, in the choices of educators and teachers, in the possibilities of children and youth, making them issues to be lived, understood, and transformed.

Years later, Simon Beames (2015) – noting once again that the term place-based education is used by many, while a deep understanding of how to translate it into teaching through local phenomena is not as obvious – highlights other characteristics useful for exploring this set of assumptions and practices in greater depth: firstly, it is recognized not only as a proposal for learning, but for education as a whole, an aspect that broadens the implications and, above all, extends the field pedagogically, and which at the same time can be applied in all school programs; moreover, it involves «the near and the far, the urban and the rural (and everything in between)» (*Ivi*, p. 28), on the one hand, and considers «the past, the present, the future» (*Ibid.*), integrating different spatial and temporal dimensions; finally, it «encompasses the interactions between the territory, human beings and wider ecosystems» (*Ibid.*), showing that it belongs to an ecological framework that integrates different subjects, objects and, more generally, whole ecosystems.

Place-based notes for biodiversity education

From the point of view of biodiversity education, several aspects identified so far appear particularly interesting.

As we have already seen, the environmental dimension is fundamental in place-based theories and practices, and not only because the chosen territory is outdoors, so much so that place-based education is often considered so close to environmental education itself that it has been called its “cousin” (Woodhouse and Knapp, 2000). Its close connection with environmental as well as scientific aspects in schools also emerges from the aforementioned review by Yemini, Engel, and Simon, in which, of the 149 contributions analyzed, 48 are environmental studies and 33 are science studies (2023, p. 11) with the explicit goal of improving environmental awareness, as well as academic performance more generally, while other disciplines are almost absent, although the approach is widely considered to be a comprehensive

educational experience, in line with the premises of the authors mainly referred to here. This explicit link with environmental issues is certainly particularly consistent with biodiversity education, but it is also an element to be taken into account in order to avoid the risk of its marginalization or sectoralization. In the same review, it emerges that very often place-based education is not part of a formal curriculum, but is the responsibility of external parties who develop dedicated projects within schools (2023, p. 11), resulting in a less significant and widespread impact, often limited to individual teachers, who in most cases choose to implement place-based education on their own (Conlon *et al.*, 2024).

However, there is an undeniable growing trend towards bringing education to places, certainly linked to the contemporary growing attention to environmental and sustainability issues, so much so that Wattchow and Brown suggest that the emergence of place-based approaches is due to «concern about the cumulative effects of modernity on our ability to respect and care for the local places we call home and the remote places we encounter when we travel» (2011, p. 51). This is a physical repositioning that also requires a conceptual one (Wattchow *et al.*, 2008, p. 18), in which places become subjects of relationship, contributing to the design of a new possible ecological education and, at the same time, to the rethinking of educational contexts as authentic spaces of life in and for the world (Guerra, 2020, 2022, 2023).

The disconnect between people and the environment, particularly the natural environment, is one of the main challenges highlighted in the review by Navarro-Perez and Tidball (2012), which aims to clarify the state of the art of biodiversity education in international literature, analyzing over 70 articles. Among other things, it emerges that the specific term “biodiversity education” appears in less than a third of the contributions, and that it is often treated more generically as environmental education or education for sustainable development, and that no article provides a precise definition of it, but rather guidelines and suggestions. Education for biodiversity also shows a growing tendency to be rooted in places, closer to real environmental issues and further away from informative and notional approaches, which are still often prevalent (Yli-Panula *et al.*, 2018), aimed in this sense at fostering a sense of connection both with the environment and with its problems regarding biodiversity loss (Cohen, 2016; Katili *et al.*, 2021).

Priority investment in specific physical areas, which, as we have observed, does not preclude but rather tends to extend the scope of analysis well beyond the boundaries, thus allows for intensive research that focuses on the depth of the study. It is precisely through in-depth study, via direct contact, that other proposals link the possibility, on the one hand, of developing an emotional bond with places, which is the basis of ecological

awareness, and, on the other, of learning and at the same time using one's learning (Judson, 2015). Depth provides the opportunity to access the connections and interconnections that traverse a territory and its community and thus promotes movement between the local and the global without losing sight of the contexts, showing instead how local problems are linked to other places in a complex network.

It is a depth that takes time, so much so that some have called their proposal “slow pedagogy of place”, emphasizing the need for immersive and recursive processes so that, in the progressive experience of a geographical place, but also of social interaction, subjective meanings and bonds can develop over time (Payne and Wattchow, 2008). Among recent studies focusing on projects related to biodiversity education (see, for example, and at opposite ends of the spectrum in terms of duration, Gass *et al.*, 2021, an experiment conducted over a limited period of time on a university campus, and Feio *et al.*, 2022, an annual project conducted with children in the early years of primary school), the value of the immersive dimension in territories typical of place-based education is sometimes highlighted. In particular, the work of Feio and colleagues has shown that direct contact with places, especially when it is continuous rather than sporadic, can have a significant impact compared to knowledge about biodiversity and awareness of its main problems. This is true as well in terms of dismantling fears and concerns, even in children who initially showed little connection with the environment due to a lack of previous opportunities.

Place-based education and biodiversity education therefore share a propensity to foster a deep connection with the environment, its resources, and its limitations, favoring an experience that is not only no longer mediated but, above all, situated in a specific context with its own specific characteristics. In this regard, it is interesting to note that the literature review carried out by Yli-Panula *et al.* (2018), which considered 317 international scientific articles relating solely to biology teaching methods that promote biodiversity education, identified 19 different methodologies, often combined with each other, showing a promising presence of forms of experiential learning, in the field or outdoors, based on investigation and problem-oriented, all of which are extremely consistent with those valued by place-based education. In general, biodiversity education also points to observational, project-based, and documentary methodologies as those most capable of enabling the collection of information, knowledge, and skills on biodiversity (Katili *et al.*, 2021; Cohen, 2016; Ramadoss, 2011) and to enable children to define the meanings and characteristics attributed to the concept itself in a situated, personal, and active way (Lindemann, 2009).

In conclusion, while the cultural perspectives and methodological dimensions of place-based approaches show elements consistent with some recent educational proposals for biodiversity, they also offer some interesting suggestions, increasingly calling for practices capable of promoting a connection, rather than the more common disconnection, between school and the environment. These practices are useful for supporting a transformative process for both and, at the same time, fertile for promoting education capable of fully addressing the lives, communities, and territories of those to whom it is addressed, thus situated, ecological, and biodiverse.

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Educating for environmental sustainability and biodiversity. A reading of international reference documents

by *Francesca Rota*

The key role of education in building a more sustainable future aware of the value of biodiversity

The issue of sustainability is increasingly at the center of contemporary debate due to challenges such as biodiversity loss, climate change, pollution, poverty, inequality, and violent conflict, which highlight the vulnerability of our one planet. The first definition of sustainable development dates back to the 1980s, when the report *Our Common Future* (WCED, 1987) stated that sustainable development consists of meeting the needs of the present without compromising the ability of future generations to meet their own needs. This definition has been referred to in all subsequent global conferences and documents, leading to the adoption of the *2030 Agenda for Sustainable Development* (UN, 2015), which is crucial to this discussion for two reasons.

The first is that the document refers to the environmental dimension of sustainability, which this contribution focuses on, placing it in close relation to the economic and social dimensions. In particular, the environmental aspect concerns the need to preserve and protect our natural environment through biodiversity conservation, responsible use of resources, climate action, waste reduction, and pollution reduction so that our planet remains habitable for future generations. In this sense, the economic sphere is about promoting sustainable, inclusive, and equitable economic growth, trying to reduce economic inequalities, creating opportunities for everyone, and promoting prosperous lives, ensuring that economic, social, and technological progress takes place in ways that respect nature. Both dimensions are also closely linked to the social one, which concerns people's well-being, with the aim of ensuring healthy lives and quality education for all, combating poverty, promoting gender equality, co-constructing peaceful, fair and inclusive societies, and supporting the health of people of all ages.

At the same time, it also concerns participation, as the achievement of all these goals requires citizens to see themselves as agents of change.

A second reason is that *Agenda 2030* recognizes education as playing a fundamental role, both as a key factor in achieving all the Sustainable Development Goals (SDGs) and as a specific goal to be achieved. In particular, Goal 4 aims to ensure inclusive and equitable quality education, promoting lifelong learning opportunities for all. More specifically, Target 4.7 emphasizes the need to promote knowledge and skills related to sustainable development through education on the environment, global citizenship, peace, gender equality, cultural diversity, and human rights.

The urgency of the challenges we are facing requires a fundamental transformation in the way we think and act, leading us on the path to sustainable development based on fairer, more inclusive, mindful, and peaceful relationships with each other and with nature (UNESCO, 2022). In this sense, the role of education for sustainability can prove crucial, as a process that aims to develop skills that enable citizens to reflect on their actions, taking into account their current and future social, cultural, economic, and environmental impact, from both a local and global perspective (UNESCO, 2017). In this way, education for sustainability can become a driving force for new cultural models and new lifestyles and ways of thinking, increasing individual and collective responsibility and promoting actions aimed at achieving common well-being (Birbes, 2022).

With specific regard to the environmental dimension, the *Recommendation on learning for the green transition and sustainable development* (Council of the European Union, 2022) highlights how, although some progress has been made in several countries, it is necessary to increasingly promote education for environmental sustainability. In fact, we need to overcome the anti-ecological way of thinking that has long dominated Western culture and has long conceived of nature as an object and human beings as subjects separate from it, thus authorizing an instrumental relationship with nature (Mortari, 2020, 2022). On the contrary, moving towards an ecological culture means promoting a sense of belonging to nature and, therefore, attitudes of care and respect towards it (Regni, 2023). Education for environmental sustainability can therefore be understood as education that seeks to promote awareness that human beings are part of nature and depend on it, supporting the development of knowledge, skills, and attitudes that enable them to be agents of change and to contribute individually and collectively to co-constructing a future that respects the planet's limits (European Commission, 2022).

It is within this framework that this contribution aims to reflect on some of the issues that emerge from the most recent international documents on education for sustainability and global citizenship, issued by the United Nations (UN, 2015; UNESCO, 2015, 2017, 2020, 2022) and the European Union (Council of the European Union, 2022; European Commission, 2022), paying particular attention to the environmental dimension and the issue of biodiversity. In this regard, it is important to note that: in most of the documents considered, education for environmental sustainability is not addressed as a separate issue, but in relation to the social and economic dimensions, in line with the holistic and complex vision of sustainability mentioned earlier, with the exception of *GreenComp. The European sustainability competence framework* (European Commission, 2022) and *Recommendation on learning for the green transition and sustainable development* (Council of the European Union, 2022), which place greater emphasis on the environmental dimension, but always in relation to social and economic aspects.

With regard more specifically to the issue of biodiversity, it can be noted that all the documents examined refer to it, starting with the *2030 Agenda for Sustainable Development* (UN, 2015), which through Goal 15 aims to «protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss» (p. 25). Recognizing the challenge of biodiversity as one of the most complex and urgent to be addressed, and recognizing that economic and social development will increasingly depend on how our planet's natural resources are managed, the *2030 Agenda* envisions a future in which the development and use of technology are respectful of biodiversity and, more generally, a world in which humanity can live in harmony with nature and all living species that are part of it. The urgency of this challenge requires a fundamental transformation of our relationships with nature and with each other, so that they become more just, inclusive, mindful, and peaceful (UNESCO, 2022). In this regard, UNESCO (2017, 2020) recognizes the role of education for sustainability in promoting knowledge, awareness, and actions aimed at conserving and restoring biodiversity as a fundamental basis for human survival, and the *Recommendation on learning for the green transition and sustainable development* (Council of the European Union, 2022) emphasizes the importance of providing everyone with equitable, inclusive, and high-quality training opportunities on biodiversity. In this regard, it should be noted that, although the documents considered do not focus much on education for biodiversity but rather on education for sustainability as a means of combating biodiversity loss, all the documents raise a number of useful issues that provide food for thought and perspectives on the subject.

Towards transformative, participatory, and continuous learning

A first issue emerging from international documents is that, in order to co-construct more sustainable societies, it is crucial to focus on the knowledge, skills, values, and attitudes that enable citizens to make decisions and take individual and collective action, and where and how these can be developed (UNESCO, 2020). Not all pedagogical approaches are in line with education for sustainability, which is defined by UNESCO (2017) as education that not only addresses issues such as biodiversity loss, but does so through a holistic and transformative approach, oriented towards action, participation, collaboration, interdisciplinarity, and transdisciplinarity.

This definition refers to Sterling's (2006) distinction between different possible responses of educational practice to the challenge of sustainability. A first possibility concerns the transmission of knowledge and content around sustainability, as if it were a subject of study in its own right and as if there were unquestionable knowledge around this concept that could be codified and transmitted. A second possibility also concerns the transmission of content, but at the same time includes critical and reflective thinking, transcending content to include values and skills. The third possibility is the one that, according to the author, succeeds in promoting truly transformative learning, and includes the first two definitions while going beyond them, as it emphasizes experience and the quality of learning «which is seen as an essentially creative, reflective, and participatory process» (p. 79). Importance is also attached to the ability to work in doubt and uncertainty, starting from a conception of knowledge as transitory, relational, and approximate, and therefore of learning as a continuous exploration through practice. In this regard, the *Recommendation on learning for the green transition and sustainable development* (Council of the European Union, 2022) suggests providing today's and tomorrow's citizens with accessible information based on facts about the biodiversity crisis, as well as opportunities to observe, explore, and care for nature from early childhood, in order to promote the development of curiosity and wonder while also valuing the natural world and its biodiversity through direct interaction with it (Guerra, 2023). In this sense, the document affirms the importance of showing that biodiversity is an issue that can be addressed at the local level, both individually and collectively. In order to fully understand the consequences of our actions on the environment and to foster greater solidarity between humanity and the biosphere, it is essential to promote an ethic of individual and collective responsibility through the active participation of everyone (Biagioli *et al.*, 2022).

Returning to the definition of education for sustainability mentioned above, UNESCO (2017) also affirms the importance of promoting lifelong learning in formal, informal, and non-formal contexts. In terms of education for biodiversity, this can mean promoting the creation of networks for environmental and biodiversity protection through collaboration with parks, forests, farms, museums, libraries, businesses, local authorities, consumer organizations, the socio-educational animation sector, and youth organizations (Council of the European Union, 2022). Systemic change, such as that required to co-create a more sustainable world, cannot be achieved solely through education that takes place within formal contexts and for a limited period of life, as it requires lifelong learning to be sustainable (European Commission, 2022). However, a critical aspect highlighted in the literature is that most research focuses on school contexts and, more generally, on the formal education of children and young people, while few studies focus on how adults, as citizens, consumers, and members of a community, can learn to live according to the principles of sustainability (Schreiber-Barsch and Mauch, 2019; Bianchi, 2020).

Young people certainly play a key role in promoting environmental awareness and are becoming increasingly active in calling for decisive change. For this reason, it is crucial that educational agencies actively involve youth in developing learning solutions for the green transition and sustainable development and in taking action in response to biodiversity loss and, more generally, to the challenges posed by sustainability (Council of the European Union, 2022), as they are directly involved in addressing the consequences of unsustainable development in the present and in the future (UNESCO, 2020). This does not mean, however, neglecting other age groups of the population, such as adults or early childhood, which have long been overlooked and are now recognized by all the documents taken into consideration. Educating for biodiversity from early childhood is, in fact, essential, given that it is in the early years of life that the foundations for building knowledge, attitudes, and values are laid, and given that changing lifestyles and habits is more complex in adulthood (Elliot, Årlemalm-Hagsér, and Davis, 2020). In this regard, research shows that promoting experiences in nature during childhood and environmentally friendly behaviors are related to the development of a feeling of connection with nature that remains in adulthood and encourages sustainable choices and lifestyles (Molinario *et al.*, 2020), as well as positive actions with regard to biodiversity conservation, such as buying eco-friendly products, reducing the use of pesticides at home, and supporting environmental protection organizations (Soga and Gaston, 2023). At the same time, research shows that experiencing contact with nature in everyday life is also of fundamental importance in adulthood in order to promote ecological

awareness and a personal commitment to implementing practices and behaviors that favor biodiversity, such as: providing bird nesting boxes in one's garden, maintaining patches of wildflowers that are more biodiverse than cultivated flower beds, consuming organic products, consuming seasonal products, and composting at home (Prévot *et al.*, 2018).

The skills needed to tackle local and global challenges of sustainability and biodiversity

In order to support lifelong learning related to environmental sustainability, and more generally to sustainability, in formal, non-formal, and informal contexts and through a transformative approach, *GreenComp* (European Commission, 2022) outlines a set of competencies «to think, plan and act with empathy, responsibility, and care for our planet» (p. 2).

To understand the premises from which this innovative document originates, it is necessary to highlight how the literature on sustainability skills is now very extensive, with the proliferation of different reference frameworks, mainly referring to higher education (for example, see Wiek, Withycombe, and Redman, 2011; Lozano *et al.*, 2017), which identify skills that are partly similar and partly different, making it difficult to identify a single framework that can serve as a guide for those working in education and beyond. In 2022, the European Union made an effort to integrate the multiple sustainability frameworks into a single framework for lifelong learning, through definitions that are intuitive and applicable to contexts other than higher education, in an attempt to formulate a shared European vision of the skills needed to understand and solve environmental crises together. This led to the creation of *GreenComp*, which identified 12 skills grouped into four areas.

The first area is called *embodying sustainability values* and refers to skills that promote reflection on one's personal values. Problems related to environmental sustainability are often defined as *wicked problems* (Rittel and Webber, 1973), i.e., complex, controversial, and constantly evolving issues for which there is no single definition or solution. In this sense, education for environmental sustainability needs to move away from teaching “correct” behavior in order to offer everyone the opportunity to identify and express their own vision, including through discussion with others (Sass *et al.*, 2020). This is in line with the competence *valuing sustainability*, which is defined in the document as a meta-competence that aims to make citizens of today and tomorrow understand how each person has their own thoughts and takes certain actions that may or may not contribute to the co-construction of a

more sustainable world. In this regard, the competence of *promoting nature* leads us to question our own conception of the relationship between humans and nature (Mortari, 2020, 2022), as it is only by recognizing that humans are part of nature, and not outside or above it, that we can develop a sense of care and respect for the environment and all forms of life that inhabit it. This competence therefore also invites educators – who are among the target audience of this document – to reflect on the importance of encouraging constant and prolonged contact with nature, recalling the concept of *nature deficit disorder* (Louv, 2005). In addition to promoting physical, mental, and psychological well-being, in line with what emerges from international (Chawla, 2015; Tillmann *et al.*, 2018) and national literature (Farnè, Bortolotti, and Terrusi, 2018; Guerra, 2020), contact with nature can promote the *ecological literacy* referred to by David Orr (1992), i.e. the ability to understand the interrelationships and interdependence between humans and natural systems. Human health is therefore closely connected to nature and, consequently, to the health of the planet. It is on this basis that *GreenComp* defines the competence of *supporting fairness* as the competence that can help us understand the link between environmental quality, justice, and equity, as well as appreciate the existence of the interests and capabilities of other species and other environmental ecosystems.

The second area of competence is called *embracing complexity in sustainability* and includes *systems thinking*, *critical thinking*, and *problem framing*. In other words, these competencies refer to the importance of taking into account the complexity of sustainability from the point of view of the close correlation between the environmental, social, and economic dimensions that comprise it and from the point of view of the deep connection between the local and global contexts. In this sense, we can refer to the concept of global citizenship education, which means «a sense of belonging to a broader community and common humanity, promoting a “global gaze” that links the local to the global and the national to the international» (UNESCO, 2015, p. 14). This concept is of fundamental importance with regard to environmental sustainability and education for biodiversity, as it invites us to consider how environmental problems, including biodiversity loss, affect the entire planet and are reflected in the lives of everyone, which is why they need to be addressed at the local level, starting with each person's responsibilities in their daily lives, but at the same time looking beyond the here and now to understand the relationships between their actions and what is happening at the global level (Calvano, 2019; Malavasi, 2020). In this sense, the *Recommendation on learning for the green transition and sustainable development* (Council of the European Union, 2022) calls on those involved in formal and non-formal education to

make issues related to biodiversity and sustainability relevant to the daily lives of learners, starting from early childhood.

GreenComp then identifies a third area, closely related to the previous two, called *envisioning sustainable futures*, which includes the skills *futures literacy*, *adaptability*, and *exploratory thinking*. All the international documents mentioned so far, in fact, invite citizens of all ages to see themselves as agents of change for the co-construction of a more sustainable world. This implies, first and foremost, the ability to imagine alternative futures that move in this direction, trying to adapt to a rapidly changing world, but also trying to use creativity to explore new possibilities for the future.

At the same time, perceiving oneself as an agent of change requires *acting for sustainability*, as emerges in *GreenComp* through the fourth and final area of skills that promote *political agency*, *collective action*, and *individual initiative*. Once again, there is a strong reference to the concept of global citizenship, as the document highlights how «by acting together and working to achieve the same goal, people can find opportunities and meet challenges to contribute effectively to solving sustainability problems at the local level. Taken together, this will have an impact at the global level» (p. 27). Developing a sense of individual and collective responsibility towards the environment requires, however, a continuous, immersive, experiential encounter with it, in order to determine a progressive sense of belonging that is essential for promoting respect and care (Guerra, 2021). Education for environmental sustainability cannot, therefore, be limited to a frontal and transmissive teaching-learning style, which often still characterizes it (Schnitzler, 2019), but must promote multidisciplinary, multidimensional, and emotional learning (Eilam and Trop, 2011). This is in line with the UNESCO (2020) statement that education for sustainability should promote the conservation and restoration of biodiversity, taking into account: a cognitive dimension of learning, which has to do with understanding current challenges and exploring alternative ideas; a social and emotional dimension, which has to do with building values, empathy towards others, and motivation for change; a behavioral dimension, which concerns taking concrete actions to promote transformation and changes in different spheres, personal, social, and political. To support those involved in education at various and different levels, the document *Education for Sustainable Development Goals. Learning Objectives* sets out in a practical way the learning objectives aimed at achieving SDG 15 of the *2030 Agenda for Sustainable Development* (UN, 2015) and thus halting biodiversity loss, as well as outlining some key issues related to biodiversity and some examples of learning approaches and methods. In this way, it is possible to both open up spaces for reflection on how we relate to the environment around us and

the different species that inhabit it, and to ensure that citizens can take action and feel personally involved, promoting a change that starts with mindset and thought and leads to actions and behaviors (Birbes, 2012).

Conclusion

In conclusion, international documents recognize education as one of the most important tools for promoting a change in the way we think and behave towards nature, so that human actions are increasingly respectful of ecosystems, starting with the enhancement of all the species that inhabit them.

In this sense, it is necessary to go beyond the transmission of knowledge and offer opportunities to observe, explore, and engage with the natural world and its biodiversity in a continuous and immersive way, during childhood but also in adulthood, in order to foster individual and collective attitudes of care and respect. It is therefore essential to cultivate an attitude that leads the citizens of today and tomorrow to question their own ideas and actions related to environmental sustainability and biodiversity conservation, as well as to formulate hypotheses, participate and collaborate with others, starting from issues that affect their own living environment but which at the same time reflect challenges of global interest. In other words, the documents invite us to relate to the world, to ourselves, and to others in an active, critical, and meaningful way (Birbes, 2012), recognizing the close relationship between human well-being, the well-being of the planet, the well-being of all other species that inhabit it, and the responsibility of each and every one of us to strive to preserve this delicate balance.

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From the variety of life to life in cities: the future of biodiversity

by *Davide Maggioni*

The complexity and value of biodiversity: genes, species, and ecosystems

The term biodiversity has now become widely used in everyday language, but its complexity and significance for life on Earth are still often underestimated. The word is a contraction of “biological” and “diversity” and refers to the variety of life in all its forms, from genes to ecosystems. It is a broad concept that encompasses not only the wealth of species on Earth, but also the relationships and processes that make life itself possible. The first formal definitions date back to the 1980s, when the term “biodiversity” was first used in academia, particularly to draw attention to the growing loss of biological variation due to human activities (Wilson, 1988). A few years later, the *Convention on Biological Diversity*, an international treaty aimed at conserving biological diversity and promoting its sustainable and equitable use, provided a precise and still valid definition, namely «the variability among living organisms from all sources, including terrestrial, marine, and aquatic ecosystems and the ecological complexes of which they are part, including diversity within species, between species, and of ecosystems». From this perspective, biodiversity manifests itself at different levels of biological organization, namely genetic, organismal, ecosystemic, and functional, which together outline the extraordinary complexity of life. These levels do not constitute a hierarchy, but rather interconnected dimensions that influence each other, spanning the natural world from individual organisms to ecosystems. Genetic diversity is often understood as the basis of the four levels of biodiversity and represents the variability of DNA among individuals, populations, and species. It governs the immense genetic mosaic that sustains life and represents the raw material of evolution, enabling populations and species to adapt to environmental changes, thereby ensuring

their ecological and evolutionary resilience (Hughes *et al.*, 2008). When this diversity is reduced, populations become more vulnerable to environmental and biological stresses, such as climate change or disease. This is widely visible in both natural and domesticated populations. For example, the loss of genetic variety in cultivated plants can increase susceptibility to pests or extreme weather events, which also compromises global food security (Khoury *et al.*, 2022).

Among the different dimensions of biodiversity, the biodiversity at the level of the organism is the most immediately perceptible. When we think of biodiversity, we likely imagine the differences between individuals of the same species or of different species. The diversity between individuals of the same species is easily observable in large organisms, but it is more complex to quantify when we observe small invertebrates, such as insects. Here, all individuals of a species may appear indistinguishable from each other, even though there are actually important differences in morphology, behavior, or ecology. Similarly, distinct species may appear identical, despite having independent evolutionary histories. These species, called “cryptic species”, are a very common phenomenon in nature and can be identified much more easily by analyzing genetic variations rather than morphological ones (Bickford *et al.*, 2007). For example, it is estimated that for each morphologically defined insect species, there are, on average, three cryptic species (Li and Wiens, 2023). This phenomenon therefore represents a significant part of biodiversity that is still unknown, with important implications for our understanding of life on Earth.

The most intuitive way to measure biodiversity is to quantify how many species are present in an environment. However, despite the fact that the current system of classification of living organisms was invented about 300 years ago by Linnaeus, we still do not know how many species inhabit the Earth. If an extraterrestrial life form arrived on Earth and asked us how many distinct life forms (species) our planet has, we would probably be embarrassed: our best answer would only be an estimate, between 5 and 10 million species (not counting microorganisms), but there is also a case to be made for much higher figures, over 100 million, or much lower ones, around 3 million (May, 2010). To date, we know of just over two million species, but estimates tell us that these are only a small part of the real biodiversity present on Earth.

This wealth is not distributed evenly across our planet. On a temporal scale, life on Earth has undergone profound changes since its appearance around 3.8 billion years ago, alternating between phases of intense diversification and mass extinction events that have reshaped ecosystems and the entire planet (Benton, 1995). Similarly, on a spatial scale, some regions

are characterized by high biodiversity, while others naturally have fewer species. Rainforests, coral reefs, and tropical soils are home to exceptional concentrations of species, some of which are endemic, i.e., unique to a specific area. In the 1980s, the concept of *biodiversity hotspots* was introduced, referring to regions that combine high biological richness, numerous endemic species, and a high degree of anthropogenic threat (Myers *et al.*, 2000). Today, there are 36 recognized hotspots, whose intact habitats cover less than 3% of the land surface but are home to over half of all vascular plants and several terrestrial vertebrates. These areas represent veritable treasures of biodiversity, but also priority conservation frontiers.

However, counting species is not enough to understand biodiversity in its entirety. Organisms interact with each other and with the physical environment and the variability of these components, as well as the variability of their interactions, constitute ecological diversity. This component of biodiversity includes both habitat diversity (such as forests, marine reefs, but also urban habitats), biological community diversity (the different combinations of species that coexist in a given environment), and ecological process diversity (including, for example, biological interactions such as predation and symbiosis, climate regulation, nutrient recycling, and so on). The loss of ecological diversity not only compromises biological variation, but also the variation in the functions of organisms and ecosystems, making them less resilient to environmental and anthropogenic disturbances.

Finally, functional diversity concerns the different ecological roles that species and communities play in nature. It describes ecosystems based on what organisms do, rather than how many species are present. In an ecosystem, two species may be very different from each other, even from an evolutionary point of view, but they may play similar ecological roles, such as two species of insects that pollinate the same plant. Alternatively, there may be many species that are functionally different, such as predators, herbivores, and decomposers, each contributing differently to the functioning of the ecosystem. The balance between different species performing the same function and between the diversity of functions allows ecosystems to maintain balance and stability in the face of change.

Functional diversity is also the basis of ecosystem services, i.e., the benefits that biodiversity provides to humanity. Ecosystems and their associated biodiversity provide a range of functions that support life and enhance human well-being. These services include provisioning services, i.e., the material goods provided by ecosystems, such as food; regulating services, i.e., the processes that help maintain the balance of ecosystems, such as plants that absorb carbon dioxide; supporting services, i.e., the

processes that provide the physical and biological basis necessary for human life and activities, such as soil formation and maintenance; cultural services, i.e., the non-material benefits derived from contact with nature, such as the inspiration that biodiversity can provide. The variety of genes, species, habitats, and functions all support these services that are useful to our species, and when biodiversity declines, these ecosystem services can also deteriorate (Hooper *et al.*, 2005).

Biodiversity is therefore not only a natural heritage to be admired and protected, but also represents: a regulator of ecological processes and the ecosystem services associated with them; an ecosystem service that contributes directly to the production of numerous goods; a final good in itself, with value, including economic value, for humans (Mace, Norris, and Fitter, 2012).

Challenges and solutions in the Anthropocene biodiversity crisis

The term Anthropocene, which literally means “age of man”, refers to the historical period in which human activities have become a force capable of significantly influencing natural processes (Crutzen, 2006). Although not yet formally recognized as a geological epoch, this term effectively describes how human impact has become predominant on Earth, profoundly and permanently altering its balance. In recent centuries, demographic expansion, industrialization, urbanization, overexploitation of resources, and extensive changes to natural habitats have radically transformed the Earth's surface. According to the concept of Earth Overshoot Day, i.e., the date on which humanity exhausts the natural resources that the Earth is able to regenerate in a year, today we consume, in less than eight months, everything that the planet can produce and renew in the same year. In other words, we live as if we had more than one and a half times the Earth's resources at our disposal. Over the last fifty years, there has also been a clear advance in this date, indicating how our use of resources is becoming progressively less sustainable.

One of the most obvious consequences of the Anthropocene is the decline in global biodiversity. Several researchers believe that humanity is currently experiencing a new mass extinction event, the so-called “sixth mass extinction,” caused directly by human activities (Barnosky *et al.*, 2011). In the history of life on Earth, there have been at least five major mass extinctions, each characterized by the loss of at least 75% of known species. Species become extinct naturally, and the “average lifespan” of a species has

been estimated at around 1-10 million years. However, during mass extinction events, the “natural” extinction rate is greatly increased, leading to a relatively rapid decline in biodiversity. The current extinction rate is estimated to be up to a thousand times higher than the natural background rate (De Vos *et al.*, 2015), meaning that species loss is no longer a normal evolutionary process, but rather a phenomenon accelerated by multiple causes. Although there is debate as to whether or not a new mass extinction event is underway, we do have confirmation that biodiversity is currently in decline.

The main causes of the biodiversity crisis are known, interconnected, and linked to human activities. We currently recognize five threats to biodiversity that, acting on both a local and global scale, are leading to a decrease in biological diversity and complexity at multiple levels: habitat loss and fragmentation, pollution, overexploitation of resources, invasive species, and global climate change.

Habitat degradation, fragmentation, and loss are considered the main causes of biodiversity loss globally. To date, a substantial part of the Earth’s surface has been modified by human activities such as agriculture, aquaculture, fishing, mining, and urban and infrastructure development: these activities reduce natural habitats and, consequently, the biodiversity they can support. In extreme cases of degradation, total habitat loss occurs, but this is often preceded by fragmentation, i.e., the division of once-continuous environments into isolated and fragmented portions. This process limits the usable space and movement of organisms, reducing population sizes as well as their connectivity. The connection between populations of the same species is in fact essential to ensure their vitality, as it allows genetic exchange, increases their ability to adapt to environmental changes, and promotes a more efficient and sustainable use of available resources. Environmental pollutants are now so widespread that few, if any, corners of the Earth remain immune. They act directly on biological resources, altering the balance of water and soil, causing mortality or physiological imbalances in organisms, whether wild, farmed, or cultivated, and once again compromising the proper functioning of ecosystems. There are many forms of pollution: light, noise, chemical, etc., resulting from excessive nutrient inputs, or linked to the accumulation of solid waste such as plastic. Pollutants can also concentrate in organisms and habitats, generating long-term effects that spread throughout the entire ecosystem. A prime example is biomagnification, whereby the concentration of toxic substances increases along the food chain: predators not only accumulate pollutants present in the environment, but also those contained in their prey and in the organisms on which their prey feeds.

Over-exploitation of resources, on the other hand, refers to the unsustainable use of the goods and services provided by biodiversity and ecosystem services. Humans have always harvested or captured plants, wild animals, and their products for various purposes, including food, material production, and the development of medicines. However, these resources are often exploited unsustainably, i.e., at a rate that exceeds their capacity to regenerate. Over-exploitation has direct effects on the species harvested, but also on many others, which are affected by extraction methods, often non-selective, and by the changes that these activities bring to natural environments. Natural populations can, however, regenerate, and today there are scientific models and tools that allow us to estimate the amount of resources that can be harvested without compromising the long-term vitality and sustainability of populations.

Nowadays, it is common to see species with names that do not accurately reflect their location. Thus, in Italy today, we find the Florida turtle or the Louisiana crayfish in freshwater environments, the beetle *Popilia japonica* in grassy and agricultural environments, and even the Atlantic blue crab in the Mediterranean Sea. All these are examples of invasive species, i.e., species that have been directly or indirectly introduced into an environment outside their natural distribution. A species is considered invasive only when it becomes established and its presence alters the ecological balance and threatens local species and habitats. The presence and spread of these species has multiple negative effects at the socioeconomic level, causing, for example, damage to infrastructure and agriculture. At the public health level, we see the spread of disease, and, of course, at the biodiversity level, we see the altering of local communities, potentially leading to the extinction of local species.

All of the aforementioned threats to biodiversity can act on different scales, having effects at both the local and global levels. However, the impact that most influences biodiversity on a global scale is undoubtedly that of climate change, which not only acts as a threat in itself but also intensifies and exacerbates all other impacts. Rising temperatures, acidification and sea level rise, ice melt, and changes in precipitation patterns are just some of the phenomena observable today, caused by human activities. These changes can have various effects on biodiversity, altering the timing of organisms, for example by making spring come earlier, compromising ecological interactions, changing the distribution of species, or even leading to the extinction of a population or species.

Faced with the biodiversity crisis, the scientific community and international institutions have developed multi-level strategies, ranging from the protection of individual species to the integrated management of

ecosystems. Modern strategies are based on a number of fundamental pillars, including monitoring, conservation, restoration, and enhancement of biodiversity. Knowledge and monitoring are essential starting points. To understand how ecosystems respond to external stimuli and pressures, a thorough understanding of the biology and ecology of organisms is necessary, accompanied by structured and continuous monitoring programs. These must be based on spatially and temporally extensive data, must take into account all components of biodiversity, from genetic to functional, and allow for a comprehensive assessment of the health status of species and ecosystems, as well as their responses to environmental stresses. For example, there are tools dedicated to assessing the conservation status of species and ecosystems, including the International Union for Conservation of Nature's Red List (*IUCN Red List*), which uses quantitative criteria to classify species according to their risk of extinction. To date, over 170,000 species have been examined according to these criteria, and almost 50,000 are threatened to varying degrees. This type of analysis allows conservation efforts to be better targeted, enabling the prioritization of species and habitats that require urgent action to ensure their survival. Conservation strategies can then be divided into *ex situ*, when species are kept outside their natural habitat in emergency situations, for example through botanical gardens and captive breeding, and *in situ* strategies, when species are protected in their ecological context. The latter is certainly the most effective strategy as it protects not only the species, but also their habitats and the evolutionary and ecological processes that sustain them. According to the *Protected Planet Report 2024*, protected areas now cover about 17% of the land and 8% of the oceans, with the global goal of reaching at least 30% of land and oceans by 2030. Protected areas are not all the same: they provide different levels of protection and allow different types of use and activities depending on conservation objectives, national regulations, and internationally recognized management categories. However, the effectiveness of a protected area depends not only on the level of protection and its size, but also on its ecological connectivity with other areas, which is why many conservation programs promote the creation of ecological corridors, or networks of connected habitats that allow species to move, reproduce, and adapt to environmental changes.

Alongside direct conservation, ecological restoration plays a key role in combating the current biodiversity crisis. This is the process of assisting the recovery of degraded, damaged, or destroyed ecosystems through targeted interventions such as the creation of ecological corridors in urban environments, reforestation, renaturalization of waterways, reconstruction of coastal habitats, or removal of invasive species. The goal of ecological

restoration is not only to restore habitats and lost biodiversity, but also to rebuild the ecosystem services that are essential to human well-being and environmental stability. Ecological restoration is now a pillar of global sustainability strategies and also has social and cultural value, contributing to improving quality of life, promoting resilience to climate change, and strengthening the link between society and nature. The value of biodiversity is not only ecological, but also cultural, social, and economic. In an increasingly urbanized society, contact with nature contributes significantly to human well-being: it improves mental health, promotes prosocial behavior, and supports global health, understood as the balance between human health, ecosystems, and the planet. At the same time, the study of biodiversity at different levels opens up new perspectives for the development of innovative products and solutions inspired by natural systems, from the discovery of new drugs, foods, and sustainable materials to the design of nature-based solutions capable of addressing major environmental and social challenges. Biodiversity thus also becomes a strategic resource for innovation and ecological transition, capable of supporting more sustainable development models.

The urban dimension of biodiversity

According to United Nations estimates, since 2007 the population living in urban areas has exceeded that living in rural areas, and currently around 58% of the world's population, or approximately 4.5 billion people, live in urban areas (United Nations, 2018). This proportion is set to grow even more in the coming decades and, at the same time, projections indicate that the total area of urbanized environments could increase, depending on different socioeconomic scenarios, by two to six times by 2100 compared to 2000 levels (Gao and O'Neill, 2020). Urbanization is therefore a phenomenon that will be difficult to reverse and, given the profound structural and ecological transformation it entails, must be managed in a sustainable manner. In this context, traditional conservation strategies, focused for example on the protection of “uncontaminated” areas separated from human activities, are becoming increasingly inadequate for cities. Instead, a new vision of urban conservation is emerging, one that recognizes cities as an integral part of ecological systems and as potential spaces for protection and ecological connection. The urban environment is not in fact a lifeless environment, but can host an array of unexpected biodiversity, capable of persisting, adapting, and evolving in anthropized contexts, giving rise to new ecosystems, namely urban ecosystems. Urban areas include a variety of environments, such as

parks, gardens, brownfield sites, canals, and vegetable gardens, and each of these elements can become an ecosystem capable of providing shelter and resources for many species of plants and animals. This biodiversity performs essential ecological functions and contributes directly to ecosystem services and human well-being.

Starting mainly in the 1970s, several researchers began to shift their focus to issues related to biodiversity and ecology in urban environments, converging in the discipline of urban ecology. In the decades that followed, global interest in this topic increased significantly, with detailed coverage of various topics, including the management and conservation of urban biodiversity, the effects of urbanization on natural populations, sustainability, and the human dimension of biodiversity in the urban environment (Collins, Magle, and Gallo, 2021). Urban ecology and conservation are now disciplines that bridge the natural and social sciences, studying not only how organisms live, interact, and adapt in an urban matrix, but also how cities can be designed to integrate nature into their processes. While cities consume resources, produce waste, and emit heat and pollutants, they can also regenerate and restore ecosystem services if designed sustainably (Grimm *et al.*, 2008). Urban biodiversity thus becomes a key element of urban resilience.

Urban expansion affects biodiversity through several mechanisms. First, it causes simplification, fragmentation, and habitat loss, whereby natural areas are divided into smaller, often isolated portions, reducing the amount of available habitat, population size, and dispersal. Second, cities generate artificial microclimates, including the “urban heat island” effect, which leads to higher average temperatures than in surrounding areas. In addition, artificial lighting and noise pollution alter the biological cycles and behavior of many organisms. Finally, cities encourage the introduction and spread of invasive species through trade, transport, and tourism. Species such as pigeons, nutria, and tiger mosquitoes are emblematic examples of organisms that thrive in urban environments. However, we know that biodiversity is present in cities and that it brings tangible benefits, often mitigating the negative effects of urbanization itself and providing important ecosystem services. For example, from an ecological point of view, urban vegetation helps to reduce temperature and air pollution and promotes water retention and soil fertility, pollinating insects ensure plant reproduction and the maintenance of complex ecological networks, while birds and bats contribute to the natural control of potentially harmful insects (Salmond *et al.*, 2016; Silva *et al.*, 2021; Aguiar *et al.*, 2021). On a social and cultural level, more and more studies show that contact with nature in cities can contribute significantly to health and human well-being, including mental health, stress reduction, and community cohesion (Gianfredi *et al.*, 2021). Parks and urban

green spaces are not only places for recreation, but also spaces for education and inclusion, becoming a laboratory for coexistence between humans and nature and for education on sustainability and environmental responsibility.

The conservation and regeneration of nature in urban environments is based on an integrated vision that recognizes the ecological, social, and cultural value of biodiversity in cities. One of the fundamental pillars is the protection and restoration of urban biodiversity, which includes the protection of remaining natural habitats, but also the renaturalization of degraded spaces and the creation of ecological corridors. The urban renaturalization approach also promotes the reduction of direct human intervention and allows nature to regenerate spontaneously. For example, reducing mowing in parks, where portions of lawn are left uncultivated, the presence of flower meadows, and clusters of trees lead to a marked increase in biodiversity and associated ecosystem services, including pollination (Biella *et al.*, 2025). Another key element is sustainable urban planning, which aims to integrate nature into the very fabric of the city. Through the use of green infrastructure and nature-based solutions, it is possible to reduce and mitigate the environmental impacts of urbanization and climate change. Careful planning that takes soil and ecosystems into account reduces fragmentation, limits land consumption, and promotes development models that are more in harmony with the natural environment. The active participation of citizens is also essential. Nature conservation in cities cannot be imposed solely by institutions, but must arise from the involvement of citizens, schools, and associations. Environmental education, the dissemination of good practices, and citizen science initiatives (i.e., the active participation of citizens in scientific research) are essential tools for raising awareness of the value of biodiversity and building a sense of responsibility towards urban natural spaces. Obviously, this also requires effective management based on collaboration between institutions, research bodies, non-governmental organizations, and the private sector. Local policies must integrate nature conservation into urban development plans and climate adaptation strategies, using scientific data and ecological indicators to guide decisions and monitor results.

Biodiversity, in its many forms, is under threat as never before, but all is not lost. Cities, often seen exclusively as enemies of nature, can become protagonists in its rebirth. The management and conservation of biodiversity in urban environments is therefore not limited to the protection of isolated species or habitats, but takes the form of a systemic approach that aims to integrate biodiversity into the urban fabric, transforming cities into more sustainable, livable, and resilient places.

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Educating for biodiversity. A systematic review of the literature

by *Greta Persico*

Forward

The aim of this paper is to review the state-of-the-art literature on education and biodiversity, to identify research trajectories, prevailing themes, results achieved and possible new challenges for the academic community and the world of education. The article takes into consideration the scientific contributions published in the decade 2013-2023, that is the time elapsed since the last review of the literature on the relevant issues (Navarro-Perez and Tidball, 2012). This text provides a general overview of the research carried out, explaining the methodological choices and providing some contextual data. The following chapter will explore the areas of interest of the biodiversity education research in greater detail. The history of the concept of “Biological Diversity”, a fusion of the two terms known as “Biodiversity”, has been extensively explored by both the natural sciences and policies, aimed at its protection and conservation. The first meaning of the term “biological diversity” was used in 1980 (Harper and Hawksworth, 1994, op. cit. in Bermudez and Liendmann-Matthies, 2020, p. 2161) by several authors with two different meanings. While for Lovejoy biological diversity meant primarily the number of species, Norse and McManus used it to describe both genetic (the amount of variability among individuals of a single species) and ecological diversity (the number of species in a community of organisms). These reduced and simple definitions, which embrace many different parameters, have been much elaborated and debated in the last three decades (Swingland 2001), as documented by Bermudez and Liendmann-Matthies (2020, p. 2161).

They continue to reconstruct the history of the term. The *US Strategy Conference on Biological Diversity* was held in 1981, and just a few years later the *National Forum on BioDiversity*, organized by Walter G. Rosen was held. In 1988 the conference proceedings were published (Wilson and Peter,

1988), entitled *Biodiversity*: the term coined a few years earlier was now in use, and Wilson and Frances attributed the authorship to Walter G. Rosen.

As acknowledged biodiversity is defined by the *Convention on Biological Diversity* as «the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems» (UNCED 1992, p. 3). In short, biodiversity occurs on three different organizational levels: (1) genetic diversity, (2) species diversity, and (3) ecosystem diversity (Fiebelkorn and Menzel, 2013, p. 1594).

Furthermore, the report of Hooper *et al.*, (2005) expressed the aforementioned “trilogy” as “entities” and further stated that not only the “number” but also the “evenness” of entity distribution matters. The attention of Hooper *et al.* (2005) to different components of biodiversity (e.g., richness, relative abundance, composition, presence/absence of key species) was based on their effects on ecosystem properties, such as productivity, carbon storage, and nutrient cycling. Hooper *et al.* (2005) also specified that the term “diversity” was used in their paper when discussing more general attributes of biodiversity, including differences in “relative abundance” and “composition.” In a more detailed approach, Díaz *et al.* (2006) incorporated the “spatial dimension” and the “interactions” between the entities of biodiversity: «number, abundance, composition, spatial distribution, and interactions of genotypes, populations, species, functional types and traits, and landscape units in a given system» (Bermudez and Lindemann-Matthies, 2020, p. 2161).

In reference to the concept of biodiversity, citing Wals (2001), Navarro-Perez and Tidball focus on «its multi-dimensional character relating to social, economic, and environmental interactions» (p. 25), and go on to argue that such complexity «makes it a difficult concept to transmit easily and meaningfully to learners» (*Ibid.*).

The two authors conclude their paper by listing four challenges that the field of education should have addressed to effectively tackle the issues that emerged from the analysis. In what follows, we summarize them: the first challenge entails defining the approach for biodiversity education and understanding how the nature and strategies of both EE and ESD programs can potentially influence biodiversity education; the second challenge refers to the difficulties posed to both educators and learners in tackling a concept that is regarded as ill-defined; the third challenge (Saito, 2013) refers to the importance of reaching different and broad audiences through a meaningful message; and the fourth challenge for education is to reconnect people and nature (Tidball and Navarro-Perez, 2012, p. 25). We believe it is useful to

bear them in mind in the analysis, to understand what has happened in the last ten years with regard to the issues raised, namely the definition of the concepts of biodiversity and biodiversity education; the multiplicity of targets to be reached, and the interest in involving people of different ages; the formal, non-formal and informal educational contexts in which to address education for biodiversity. Last but not least, the desired reconnection of the young and elderly with nature, an issue widely debated in literature (i.e., Van Weelie, 2002; Louv, 2005; Lindemann-Mathies *et al.*, 2005, 2007, 2009), and to be further explored with respect to the specific field of biodiversity education.

The analysis of the papers selected for this review led to the division of the research into macro thematic areas that will be explored in greater depth in what follows. The excursus is only one of the possible ways of going through the documents: it should therefore not be considered the only one, nor exhaustive in scope. The same attention must be paid to the few lines of description of most of the research, briefly described below. This is perhaps a superfluous clarification, given the space requirements of the text, but we feel it is necessary to specify it, as we are aware of how much information, how many details and how much complexity of the results achieved can only be hinted at. Regrettably, some of the works are only cited, and the research was explicitly mentioned in only one paragraph, but could have provided elements of interest in others as well. It is evident that to orient our work and offer a clear path of analysis in the complexity of the materials to the reader, choices have been made that inevitably lead to greater or lesser visibility of certain aspects of both individual research and the entire corpus of research.

Method notes

For the literature review we considered over 70 publications, including articles and book chapters. The publications were found primarily online, through the PROMETEO portal of the University of Milan Bicocca, a catalogue consisting of the holdings of 16,857 libraries worldwide. As already mentioned, considering the time frame covered by the work (Navarro -Perez and Tidball, 2012), we have chosen to refer to the texts published between 2013 and 2023. In the first phase, the key terms used for the search were the same as those used by the authors of the previous review, namely: “biodiversity education”, “biodiversity awareness”, “biodiversity outreach”, “biodiversity education in cities”. We later also included terms in Italian, such as: “educazione alla biodiversità”, “biodiversità educare a”, “biodiversità”, “pedagogia dell’ambiente”, “pedagogia ambientale”. A limited number of

publications explicitly contain among keywords or in the title the words “biodiversity education” in association with each other, while the word “biodiversity” alone appears in the title more frequently, although not in all the remaining publications. Nine publications have the words “biodiversity education” in the title, while two texts refer to “education for biodiversity” or “biodiversity and education”. Only four publications use “biodiversity education” as a keyword. These publications are extremely diverse, highlighting the heterogeneity of the topics covered and, at the same time, demonstrating the complexity of defining the scope of this research field.

An initial selection of the papers took place by excluding from the collection publications, which although pertaining to the field of education and environmental sustainability, did not explicitly refer to the term “biodiversity” in the title, keywords, or text. Subsequently, to identify the issues covered by the research, an analysis of the contents was carried out. This analysis made it possible to identify macro-areas reported in the following chapter.

Finally, other elements useful for providing a comprehensive picture of the state of the art of literature were also considered. By way of example, we refer to methodological choices, to the people or groups targeted by the research, and to the expertise of those who conducted it, as well as to the type of journals chosen for publication. The collected texts are written almost entirely in English apart from two texts written in Japanese. Furthermore, we observed that comparative studies, both at national and international level, are rather limited.

An overview of publications

Below are some general considerations that provide an initial overview of the publications included in this review. The information provided should be considered as indicators of trends, as some publications may have been overlooked during the search for texts and have not been included here. The corpus consists of contributions of different kinds (e.g., reviews, theoretical reflections, and case studies), which may generate inconsistencies in a strictly quantitative analysis by type of text. An initial estimate concerns the trend in the number of publications over the years considered. With the exception of 2016, the year in which an edited volume (Castro *et al.*, 2016) containing several contributions by different authors was published, the years with the greatest increase are the most recent, namely 2021 and 2023, highlighting a growing interest in the topic. More than thirty journals have hosted the publications. Only in a few cases are there multiple publications

in the same journal. Among these journals, seven include the term “education” in their name, while in most cases they are journals focused on the natural sciences. Science education is the focus of the journal in only two cases. Just as the journals are predominantly related to the natural sciences, the expertise of the authors of the texts also shows a similar trend: their institutional affiliation or field of specialization frequently refers to the natural sciences and less frequently to purely educational fields, such as pedagogy or educational sciences. In some cases, there is co-authorship between professionals in the natural sciences and the field of pedagogy, with the latter most frequently represented by the teaching profession. It is therefore quite clear that the knowledge mobilized to promote biodiversity education is mainly rooted in the natural sciences and science education. One example is the study by Yli-Panula *et al.* (2018), which aims to survey the teaching methods used in biology to promote biodiversity education in Finnish secondary schools. In presenting their findings, the authors point out that nineteen different methodologies were found in the articles analyzed: «The most commonly used teaching methods to promote biodiversity learning were experiential learning, teacher-led presentation of the topic, group work, ICT (information and communication technologies), and interactive learning. Typical biology teaching methods, including long-term problem-oriented experimental projects and research-based outdoor or field learning, were used by teachers in teaching biodiversity. Outdoor learning and fieldwork included activities organized in outdoor settings, often natural, in the virtual world or in real nature» (Yli-Panula *et al.*, 2018, p. 9). The authors continue their analysis of the type of knowledge taught, identifying four types: factual, conceptual, methodological, and metacognitive (Yli-Panula *et al.*, 2018, p. 11).

Considering the target groups with which the research was conducted, a preliminary analysis reveals a certain heterogeneity: there is research carried out with small children and primary school children, as well as with adults, zoo and aquarium visitors, and environmental operators. A more detailed analysis reveals that high school and early university students dominate the scene and are most involved in biodiversity research. This trend could be indicative of two elements that we believe are worthy of interest: on the one hand, it could highlight a contradiction with what emerges from the literature classically defined as environmental education, according to which early contact with nature could encourage an increase in interest and predisposition to care for nature itself (Guerra, 2021a, 2021b). On the other hand, it could be symptomatic of the content and objectives implicitly attributed to biodiversity education, i.e., designed and intended for more

educated young students who already possess certain knowledge deemed useful for understanding issues related to biodiversity and its conservation.

With regard to the methodological choices used to conduct the research, it should be noted that the most widespread are traditional methodologies (e.g., surveys, interviews, focus groups, case studies). At the same time, it is possible to note, albeit to a lesser extent, the use of participatory, experiential, creative, and visual methodologies.

Towards defining the scope of interest of pedagogical research for biodiversity

The literature considered so far provides a variety of definitions of biodiversity education in relation to environmental education. This aspect, namely the epistemological autonomy of biodiversity education with respect to environmental education, emerges from the comparison between those who identify biodiversity education as an ill-defined concept, i.e., one of those concepts that have multiple interpretations, are difficult to define, are loaded with values or norms, and are multidimensional (Navarro-Perez and Tidball, 2012) and those who contest these definitional limits, claiming that biodiversity education should be included within the scope of environmental education (Saito, 2013). Saito, citing Kassas (2002a), lists aspects of environmental education that also serve as a key to interpreting biodiversity education. These are, in particular, emotional aspects, scientific and ecological aspects, ethical aspects, and political aspects. Saito's (2013) work aims to analyze the relationship between environmental education and attention to biodiversity and to present a theoretical and methodological framework to strengthen this integration in terms of application. Saito places biodiversity education within the context of environmental education, exploring the reasons and epistemological premises established by the 1977 *Intergovernmental Conference on Environmental Education* in Tbilisi. One of the first definitions of environmental education drafted by UNESCO states that its purpose is to provide every person with the opportunity to acquire the knowledge, values, attitudes, commitment, and skills necessary to protect and improve the environment (UNESCO, 1978, p. 26). Also referring to UNESCO recommendations, Saito (2013, p. 15) emphasizes that environmental education should create a closer link between educational processes and real life, building its activities around the environmental problems that specific communities face and focusing analysis on them through a comprehensive interdisciplinary approach that allows for a proper understanding of environmental issues. According to some publications, this

definition can also be easily adapted to biodiversity education, which is defined in various ways. Gass *et al.*, for example, define «biodiversity education as the teaching of variety of life on earth, as well as reflecting the call in Article 13 of the Convention on Biological Diversity (CBD) to educate people about the importance and conservation of biodiversity (CBD – Article 13, 2006)» (Gass *et al.*, 2021, p. 1539). Then there is the approach of those who tend to emphasize the multidimensional nature of the environmental issue in relation to biodiversity; an example of this is the work of Fiebelkorn and Menzel (2013), in which we read that «the biodiversity education program has an even broader scope as it also includes the global and socio-economic spheres that are an integral part of education for sustainable development (Kyburz-Graber *et al.*, 2006; Åhlberg, Lehmuskallio, and Lehmuskallio, 2007; Menzel and Bögeholz, 2008). In this context, biodiversity can serve as a model for discussing local-global challenges and socio-scientific challenges in science classrooms (Gayford, 2000; Menzel and Bögeholz, 2009)» (Fiebelkorn and Menzel, 2013, p. 1595).

Furthermore, Wiegmann and Zabel (2013) draw attention to the potential risks associated with the different meanings attributed to both the term “biodiversity” and “biodiversity education”. Biodiversity has different meanings and is defined specifically for each sector. This diversity of perspectives makes it difficult for students to grasp the meaning, navigate the debate on biodiversity loss, and advocate for change. In this context, some studies have investigated how environmental learning in the field of biodiversity can actually work (Littledyke, 2008; Franc *et al.*, 2013; Chalmin-Pui and Perkins, 2017; Beery and Jørgensen, 2018; Schneiderhan-Opel and Bogner, 2020). The affective dimension, expressed in physical and sensory experiences in nature, in individual relationships with living organisms, and in love for nature, is emphasized and considered essential for understanding biodiversity (Littledyke, 2008; Franc *et al.*, 2013; Beery and Jørgensen, 2018). Considering the biographical-individual dimension and connecting it to scientific knowledge may perhaps help young students to engage with the different meanings associated with biodiversity and recognize its value in and of itself.

Furthermore, this approach is believed to represent potential for biodiversity education, given that the teaching strategy reflects respective understandings, objectives, and interests and reveals its normative character of biodiversity rather than hiding it (Wiegmann and Zabel, 2021, p. 1246).

Most studies agree that biodiversity is a complex concept involving environmental, social, economic, and political issues, and that biodiversity education is a field of research and intervention that cannot ignore these local and global scenarios, as well as the involvement of individuals on a biographical, emotional, and experiential level. The research considered also allows us to outline guidelines that are considered significant in defining the status of biodiversity education. The latter should offer educational opportunities aimed at acquiring a scientific perspective on biodiversity and, at the same time, encourage reflection on personal experiences in relation to the natural environment, without excluding the emotional dimension. Similarly, some of the research shows that this area of investigation is not immune to power imbalances. The work of Tumbaga *et al.*, carried out in the Philippines, for example, highlights the risk inherent in the choice of terminology used when it does not take into account the linguistic biases between the world of research and the subjectivity involved in it (Tumbaga *et al.*, 2021, p. 4705). The study found that the term “biodiversity” was unknown to most of the people they contacted during their research and that its use in the fieldwork created confusion because the term was not used in the dialects spoken by the population involved in the research. “Biodiversity” was therefore found to be a “Western” term lacking in content, whereas people’s knowledge of the protected areas in which they live is not lacking in content.

A particularly interesting study by Cohen was published in 2022: a bibliometric analysis aimed at denouncing the lack of information on women naturalists in scientific knowledge. This research begins with an attempt to answer the following questions: When, where, and why did women naturalists not receive the attention their achievements deserved? What resources are available to teachers to deepen their knowledge of these scientists, and how can they be used in the classroom? To answer these questions, the author conducted a bibliometric analysis, following which ten female naturalists were chosen from the publications as examples to: maximize diversity in terms of country of origin and background, ensure different approaches to the study of natural history, represent each of the five periods of study, and highlight the period in which conservation awareness emerged (Cohen, 2022, p. 16). In addressing this gender imbalance that characterizes study programs and the world of natural sciences, the text is useful in giving visibility to female naturalist scientists and their contribution to the discipline, as well as stimulating reflection on the involvement of students who identify with underrepresented groups and are therefore more at risk of marginalization.

Conclusions

In this chapter, we have presented some general aspects regarding the review of literature on publications dealing with biodiversity education over the last ten years.

Starting from the debate, initially purely biological, on the definition of the concept of biodiversity, we then returned to the multiplicity of definitions that have been attributed over time to the scope and aims of biodiversity education, often interpreted as content and method for “gaining experience” and, through this, contributing to an increase in individual and collective knowledge. This meaning brings together and relaunches the legacy of environmental education in relation to the importance of the relational dimension between the subject and the environment, thus promoting processes of awareness and transformation of individual behavior.

However, it should be pointed out how the experiential dimension is interpreted and proposed in the research considered for this review. The experiential interpretation of biodiversity education also seems to be the one that has best taken up the challenge of «reconnecting people with nature», as proposed by Navarro-Perez and Tidball (2012, p. 25).

At the same time, biodiversity education is evoked in reference to proposals that are strongly characterized by a didactic and frontal approach, i.e., aimed at teaching and learning specific and predetermined content. In this case, we can refer to a true biodiversity teaching approach that presents a heterogeneity of teaching methods and topics such as to blur the boundaries that define its frankly vast scope of interest.

Furthermore, while it is true that research demonstrates the breadth and heterogeneity of the audience reached, as hoped for by Navarro-Perez and Tidball (2012), it is equally true that this seems to occur mainly in the form of awareness-raising and one-way information, while more rarely it involves active, long-term involvement through structured proposals that involve a network of stakeholders in multi-level projects.

As we will explore further in the next chapter, education in this case seems to be interpreted in the sense of awareness-raising activities, almost as if to affirm an overlap with knowledge dissemination actions. Biodiversity education can in fact include actions that we would define as awareness-raising and information for specific target groups, which are heterogeneous in terms of age, characteristics, and sample size. As we will see, this includes Citizen Science actions as well as experiences aimed at self-experimentation in relation to the natural environment, and furthermore, the development of a sense of place (Ardoin, 2006; Semken, and Freeman, 2008). What seems to be underrepresented, if not almost completely absent, even in research

more oriented towards an experiential approach, is the possibility for those involved (whether minors, young people, or adults) to conduct explorations and thus activate individual and self-determined research processes: even those proposals that are less characterized by a didactic approach are in fact aimed at learning, validating, and measuring specific knowledge or skills predetermined by adults, whether they are researchers or teachers.

In conclusion, or rather at the beginning of the literature review proposed in the next chapter, we believe it is reasonable to state that, while noting elements of continuity with the field of environmental education research, there are also some specific aspects that characterize biodiversity education, which will be outlined in the following paper.

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Pedagogical research for biodiversity.

Topics and areas of interest

by *Greta Persico*

Forward

In this chapter, we will examine the texts selected for the literature review, organized here into broad thematic areas. Before proceeding, however, a methodological premise is necessary: the proposed excursus is only one of the possible ways of reviewing the documents; it is not the only one and, as it is partial, does not claim to be exhaustive. In order to offer an analysis that is as clear and comprehensive as possible, choices have been made that inevitably result in greater or lesser visibility of specific aspects of individual studies. Despite our best efforts, some of the works are only briefly mentioned here. Furthermore, with rare exceptions, each study has been explicitly cited in reference to the most relevant macro-area, although in many cases the contributions provide elements of cross-cutting interest, which are discussed in the conclusion.

Knowledge and imagination around the concept of biodiversity

A first significant body of research, the second most substantial from a numerical point of view, addresses the concept and the level of knowledge of biodiversity in different target groups. One of the few comparative studies we have encountered was carried out in Germany and Costa Rica, (Fiebelkorn and Menzel, 2013, p. 1593), and investigated teachers' conceptions of the terminology, as well as their understanding of the distribution and loss of biodiversity. In discussing the results of the work, the authors point out that the study «revealed that 20 years after the commencement of the Convention on Biological Diversity, student teachers from Costa Rica and Germany seem

to have a somewhat naïve, rather than scientific, understanding of the terminology, distribution, and loss of biodiversity» (Fienelkorn and Menzel, 2013, p. 1607). Furthermore, although the majority of students mentioned socioeconomic drivers as a cause of biodiversity loss, only one participant from Costa Rica considered their transnational nature, realizing that «the socioeconomic pressure induced from industrialized countries was causing a loss of biodiversity in developing countries» (Fiebelkorn and Menzel, 2013, p. 1606). The various research findings reveal both a lack of knowledge about the concept and issues related to biodiversity and a lack of awareness, except among a limited number of people at both the local and global levels, of what causes biodiversity loss.

Another study conducted in Argentina aimed «to identify high school students' conceptual models of biodiversity, assess their conceptual understanding of biodiversity in relation to scientific definitions, and analyze the influence of gender and school location on students' understanding of biodiversity» (Bermudez and Lindemann-Matthies, 2020, p. 2159). The methodology used is the “scenario approach” to represent different components of biodiversity. The scenarios depict plausible alternative situations based on a particular set of assumptions, which projects the impact of management decisions on biodiversity (Díaz *et al.*, 2015b). The research revealed students' restricted conceptual understanding of biodiversity since few components were integrated into the conceptualization of biodiversity (“master” level). In addition, students' conceptual frameworks of the components of biodiversity were not related to school location or gender, which is in line with Prokop *et al.*, (2008), who also found no relationship between gender and conservation decisions (Bermudez and Lindemann-Matthies, 2020, p. 2182).

Other research (Araujo *et al.*, 2023) investigates teachers' approach to teaching biodiversity through an evolutionary perspective, and particularly the use of the heat chart in biology lessons. Moreover, there is research that focuses on citizens' knowledge of biodiversity-related issues. Specifically, we refer to the works of Bamberg *et al.*, (2023) who proposes a revision of the nature awareness instrument, used by the German Federal Agency for Nature Conservation for monitoring the biodiversity awareness of the German population; as well as the work aimed at developing a better understanding of how the public understands and interacts with urban biodiversity, particularly in comparison to subject matter experts (Campbell-Arvai, 2019). From this last contribution it emerges that

the terms citizens associated with biodiversity included: nature, interconnectedness, interesting, and harmonious; three interviewees described biodiversity as a

measurement, i.e., like temperature, in that it varies with the complexity or harshness of the environment. However, the term “biodiversity” was also described as an uncommon and academic word (Campbell-Arvai, 2019, p. 412).

Nevertheless, the interviewees identified the following drivers of biodiversity loss: (1) habitat degradation, (2) knowledge, values, and decision-making, (3) habitat loss, and (4) habitat fragmentation (*Ivi*, p. 423), thus providing a detailed understanding of the issue.

Pedagogical proposals and educational tools to promote biodiversity education

The largest body of research describes the experimentation of pedagogical proposals and educational tools specifically designed to promote biodiversity education pathways and experiences. The work of Cohen Joel I., (2016) aimed at offering teachers a biodiversity lesson that incorporates a deliberately simplified indicator of Anthropocene events and whether a species became extinct or, after a call to action, was able to recover, either in the wild or in captivity. Through the use of the Anthropocene Species Event Indicator (ASEI) and the Red List of Threatened Species, produced by the International Union for the Conservation of Nature (IUCN), the author intends to suggest «new pedagogies to help students use accessible data and generate their own studies of biodiversity and extinction, which will increase their awareness of declines in species diversity» (Cohen, 2016, p. 294). The research carried out by Cohen is extremely complex, and offers students and teachers stimuli and operational proposals, that allow them to explore aspects related to the Anthropocene and biodiversity. These range from the collection of information on some species, to their comparison with data previously recorded, to the study of the situation and events in animals at risk of extinction or that have become extinct, to the involvement of families through a letter on biodiversity-related issues written by students, and to evaluation questionnaires.

The research carried out in Indonesia on the island of Lombok, (Hadiprayitno *et al.*, 2023) intended to develop instructional tools for biodiversity, which aim to improve students' scientific literacy and higher-order thinking skills: also in this case the objective of the authors was to achieve

instructional tools consisting of lesson plans, teaching materials, student worksheets, scientific literacy assessment instruments, and higher-order thinking skills (Hadiprayitno *et al.*, 2023, p. 2).

The research group was interested in investigating the lack of ability to link the knowledge of biology to issues affecting everyday life. The discussion with teachers also highlighted how they «are also aware of the lack of attention to learning resources that are close to students' lives and the harmony between material concepts and examples of problems in the surrounding environment» (Ivi, p. 6).

Other studies (Majestic and Thanh Hoi, 2019) introduce integrated methods, teaching other researchers' methods and techniques to integrate nature and biodiversity conservation education into teaching in secondary schools in Vietnam, which contributes to the development of knowledge and skills on nature and biodiversity. In presenting the state of the art of Environmental Education in Vietnam, and how general school curricula can boost attention on issues related to biodiversity, the authors refer to the concept of *integrated teaching*, defining it as an approach that aims to organize learning activities, in which students learn to use a combination of knowledge and skills in meaningful and close-to-life situations. This approach is divided into three levels:

full integration is done when most of the lesson's knowledge is also the knowledge of nature and biodiversity conservation. [...] Partial integration is done when a part of knowledge of the lesson has contents about education on nature and biodiversity conservation. [...] Connected: When some content of the lesson is related to the issue of education of nature and biodiversity conservation, but it is not clear in the content of the lesson (Oai and Thanh Hoi, 2019, p. 7).

With regard to biodiversity content, this approach can be implemented by integrating such content into classroom lessons or as a separate topic linked to subjects in the school curriculum, although it can be explored in greater depth through various types of activities, including extracurricular activities.

Continuing the excursus, we will briefly present below some of the research, that more evidently than others emphasizes the exploratory and experiential dimension.

A study of Matos *et al.*, (2022) carried out in the Azores Islands by a composite team provides an interdisciplinary research, in which there were professionals with expertise in the fields of biology, nature conservation, environmental education, environmental psychology, and human-computer interaction design. The project's overarching objective is to develop, design, and evaluate mediated modes of learning in natural environments, involving

children and teenagers. The methodological approach chosen by this research group refers to two theoretical frameworks. The first is the Cultural Probes technique (CP), described as a «technique that often entails creating packages presenting participants with a series of evocative tasks. Packages typically contain maps, postcards, disposable cameras, diaries, and other familiar objects selected for exploring a given context» (*Ivi*, p. 3); the second frame refers to Inquiry Based Learning (IBL), which proposes a “learning through questioning” approach. Starting from these premises, a toolkit has been designed and implemented, aimed at the exploration of nature-rich environments in the form of a step-by-step journey by children and adolescents. The aim of the proposal is to understand the ways of interaction with the environment and engagement with respect to biodiversity in site-specific environments. In close dialogue with the EE literature, the research does not fail to highlight some risks of the two approaches presented, not least the question: what level of guidance in questioning activities can CP provide in the context of place-based learning in EE?

Schaal *et al.*, (2015) in a study conducted in Germany analyse the BioDiv2Go (Biodiversity to go) project, whose aim is to create sensuous experiences and an appreciation of biodiversity using mobile technology. The research has the objective of exploring the connection between location-based learning and digital media, to link the real and virtual worlds. The project under consideration highlights how the combination of a narrative component, a performative dimension (expressed in online gaming as well as in nature explorations, in individual or small group activities), combined with a playful approach, can contribute to an increase in interest in local biodiversity among adolescents. Geospatial exploration through the proposal of modules created with GeoPDF is at the centre of the research of Trautmann *et al.*, (2013, p. 467), which underlines how through guided exploration of data portrayed in maps and graphs, students can develop data analysis skills and use critical thinking to build understanding of key concepts related to biodiversity.

Instead, Khelifa and Mahdjoub (2021) propose an exclusively virtual tool, called the EcoDragons, that educates players about the basic principles of ecology and conservation from the perspective of dragonflies. «The objective of the game is to occupy as many habitats as possible and maintain biodiversity in the environment using different ecological, biological, and evolutionary processes as well as conservation measures to face anthropogenic disturbance» (Khelifa and Mahdjoub, 2021, p. 10). In describing the game, the authors highlight the content and educational implications of each of the card types present in the game and clarify the potential of a tool intended for a wide audience of players.

In the work of Hardy and Hardy (2018), who analyzed the Syllabi of about 60 courses of interest for Biodiversity education, it is highlighted how a huge amount of data collected during lessons, seminars and outdoor activities included in the educational program are lost, due to the lack of practice of valorizing them with the use of tools such as online platforms (e.g. NatureAtlas). According to the authors, the project had accomplished the very important objectives of raising awareness and appreciation of the value of these technologies and their capacity to enhance efforts in the study and conservation of biodiversity. These data also indicate that the classroom is more than a mere training ground for future biodiversity scientists; it also is a potential recruiting ground for future citizen-scientists (Hardy and Hardy, 2018, p. 507).

Parreño *et al.* (2022, p.139) explored representations of biodiversity in puzzle games, and identified which representations of nature may unwillingly lead to “misconceptions” of biodiversity themes and processes, and an over-simplification of the relationship between people and nature. This research focuses on the ways, in which people develop understandings of biodiversity outside formal science education, and how this should be a key issue for transdisciplinary research, given the pressing need for biodiversity conservation.

Consistently with research that aims to highlight the link between biodiversity and everyday life, we come across a study, which as indicated in the title of the publication itself, intends to combine educational outreach with scientific research (Steinke *et al.*, 2017). This objective is pursued through the analysis of the project “The School Malaise Trap Program (SMTP)”, a biodiversity education proposal that invites primary school students to ask themselves who lives in their school garden. The heart of the initiative implemented by schools across Canada involves the installation of a Malaise Trap in the school garden, after which two weeks of observation, data collection, sharing, analysis, and DNA coding of the collected samples are carried out. Educational staff and teachers receive supplementary materials and tools, and data can be shared and compared with those collected across Canada. Watsa *et al.*, (2020), in a research conducted in Peru provide step-by-step protocols as a blueprint for a terrestrial conservation genetics field training program that uses low-cost, portable devices to conduct genomics-based training directly in biodiverse habitat countries. In the conclusions of the study, the research team emphasizes how portable sequencing technology can help democratize scientific research and conservation efforts. «A necessary step to implement a new conservation tool is training local science educators and conservationists in areas in which research funding and infrastructure are lacking» (Watsa *et al.*, 2020, p. 7).

Researcher Earl and colleagues (2018) propose a reflection that focuses on an interpretive case study in education for sustainability (EfS) that applies VanWynsberghe and Herman's (2015, 2016) adaptive education as pedagogy, as a theory of change based on habit disruption that might address this question of behaviour change through education. Through the presentation of action-research, conducted with a group of students starting from the analysis of their unsustainable behaviours, the text presents some reflections formulated with the analysis of the constituent elements of adaptive education, i.e. stakeholders, real-world learning, off campus, transdisciplinary and non-traditional rewards.

The work of Feio *et al.*, (2022) on the other hand, addresses the aquatic environment, which is not at all recurrent in the research considered in a project lasting for about a year conducted in Portugal (Coimbra) with primary school students. The research aimed at increasing knowledge of the ecosystems present in urban watercourses and their problems. Among the main results we believe it is interesting to highlight the following: after one year of activities and close contact with streams, students' knowledge on the aquatic and terrestrial biodiversity associated with rivers, and the awareness of their main problems increased significantly while their fears and concerns decreased; children are only temporarily disconnected due to factors such as the environment in which they live, the influences and pressures of peers and the assimilation of the ideas transmitted by the family. A further element of interest concerns the confirmation that «environmental programs should not be restricted to sporadic activities as a longer duration is more likely to change behaviors» (Feio *et al.*, 2022, p. 15).

Another group of research explored the relationship between biodiversity and nutrition. Afonso *et al.*, (2021) conducted research with a group of primary school students in Portugal, with the proposal of exploring and experimenting with different types of the same plant through multisensory stimulation. The aim of the study was to understand whether a greater knowledge of biodiversity could favor the consumption of plants. Similarly, Fischer *et al.*, (2019) carried out research to better characterize the concept of “biodiverse edible school” in Germany, to connect food production and consumption with biodiversity at the local level, thus promoting direct knowledge of urban nature and healthy eating. Therein, the involvement of local stakeholders was of particular interest both for the management of green areas, as well as in networks with local producers, and for the setting up of a school kitchen for processing the harvested products. Among the research findings, in addition to many positive results, some critical issues were identified related to the consumption of fruits and vegetables grown in urban contexts, where significant levels of pollution can be detected. Instead, Mota *et al.*, (2021),

conducted a study with nutrition education students and teachers in Brazil, based on the Garden-Based Learning Method. The intervention aimed both at analysing training curricula and at experimenting with an experiential approach, to explore the close relationship between biodiversity and healthy eating. In their findings, all the research reported here underlines the added value of the experiential dimension in the research and learning process.

Promoting participation and citizenship through biodiversity research

Among the research on biodiversity education, where education is instrumentalized in a broad sense in reference to non-formal or informal education contexts, studies carried out in both urban and rural contexts involving citizenship or with specific target groups, provide interesting insights. It is a body of research that is extremely diverse in terms of geographical location and objectives. However, considering that recent studies have found that biodiversity conservation success is often grounded in local population support, which in turn is strongly influenced by the perception of these resources and the effects that are experienced by local communities (Tonin and Lucaroni 2017, op. cit. in Tumbaga, 2021) we believe it would be very useful to explore this further. In the next paragraph, we will therefore briefly summarize some of the texts we encountered, retracing them in chronological order starting from the most recent.

Deparis *et al.*, (2023) carried out a study in collaboration with the public administration of the city of Blois, France, aimed at analyzing how municipal service directors, field operatives and pedestrians relate to spontaneous vegetation in streets; a place-based integrative approach to transform people–nature relationships. This study is of particular interest for the proposed methodology, which among other characteristics is based on the involvement and collaboration between local administrators, green care professionals, citizens, and the research group. Another study (Tumbaga *et al.*, 2021) aimed at determining the community participation toward biodiversity conservation in two communities in The Philippines. Among the research objectives was to understand the level of knowledge of biodiversity and biodiversity loss among the inhabitants, in relation to which, the research group reported that the knowledge of the community members on the threats and the importance of biodiversity is considered high, especially on the idea that biodiversity provides numerous services to people and the environment. The attitude of the community toward biodiversity is somewhat positive yet self-centered. This is attributed to the people’s reliance on experts and modern technology

to conserve biodiversity, and to the passive attitude of some residents toward the need to report illegal activities leading to biodiversity loss. «Community participation in the two barangays (villages) is significantly different. The difference is related to the number of programs and projects implemented in the area, and on the socioeconomic characteristics of the community or the availability of job opportunities for the locals» (*Ivi*, 2021, p. 4713).

The study of Nuraeni and Rustaman (2019) also addressed the relationship between local populations and biodiversity focusing on the traditional knowledge of medicinal plants used for health of women, and their opinion on the importance of such knowledge integrated into the school *curriculum*. Moreover, the proposal by Laladhas *et al.*, (2013) also seems to move on the same premises to create the People's biodiversity register in India, that is a register in which it is possible to collect people's knowledge at a local level so as to make it a common heritage.

A comparative study on three areas in South-Eastern Kenya was conducted between 2016 and 2018 to explore ecological awareness, protection attitudes and environmental communication in all the target areas. According to the authors the principles of co-management and Participatory Forest Management (PFM) offer a valuable framework for conserving tropical forests. «However, the degree to which these principles can be implemented is dependent on distinct and discreet social-ecological factors that can contribute and reinforce inverse trade-offs and significantly undermine positive conservation outcomes» (Nzau *et al.*, 2022, p. 1325).

Research conducted in several school yards in the city of Harare, Zimbabwe has highlighted how these natural areas, although limited, represent a resource for biodiversity conservation, and should therefore be enhanced in this view (Muvengwi *et al.*, 2019).

The work by Suárez-López and Eugenio (2018) presents an excursus on the development of Environmental Education in Latin America by declining it as a political-pedagogic perspective, and introducing the theories of Critical EE.

Critical EE is based on political ecology, the critical theory, and the complexity paradigm (Da Costa-Lima 2009). It emphasizes the fact that environmental issues are multidimensional and interdisciplinary and cannot be isolated from social problems (Da Costa-Lima 2009), and it promotes the construction of an “epistemology of the South” (De Sousa-Santos 2010) (Suárez-López and Eugenio, 2018, p. 1103).

Subsequently, the authors discuss the value of wild Botanic Gardens, present in significant numbers and well distributed throughout the territory. They are considered places of biodiversity protection with their high potential in the promotion of innovative environmental programs in Latin America. By way

of example, the authors identify three types of activities such as: open activities (e.g. freely exploring different areas of the BG individually or in groups), guided activities (e.g. investigating specific characteristics of the vegetation through an experiential approach), structured activities (e.g. answering a questionnaire).

Attributable to the area of interest of research aimed at promoting participation, another field explored by some of the research concerns Citizen Science actions. According to Silvertown (2009), there are three factors that have influenced the increase in Citizen Sciences initiatives over time: the first was the easy availability of technical tools, the second the realization among scientists of the vast resource represented by the general public, and the third the recent requirement by funding agencies for science outreach. These factors have also prompted researchers interested in biodiversity education to first use, and then theoretically reflect on Citizen Science tools and methods.

Other research investigates the role that Citizen Science initiatives can have both in promoting knowledge of issues related to biodiversity and in engaging an increasingly wider public in initiatives aimed at its conservation (Donnelly *et al.*, 2014; Echeverria *et al.*, 2021). The work of Donnelly *et al.* (2014) carried out in Ireland, highlights how citizen scientists play an important role in helping fulfil conservation and biodiversity legislative requirements at all levels, and at the same time it reveals how the question of age often crops up when discussing volunteers in citizen science and there appears to be a bias towards older citizens (Wolcott *et al.*, 2008; Roxby 2011). The work of Echeverria *et al.* (2021), conducted with high school students in Spain, was aimed at creating a virtual herbarium through the use of iNaturalist during outdoor activities carried out within the area called Basaula Reserve. In this case, the research group highlights two positive aspects, although using the App posed some critical issues, ranging from the need to familiarize oneself with its operation to the availability of data for the Internet connection. First and foremost, it emerges that using the App leads both to the achievement of specific contingent educational objectives, and to the awareness of being able to experiment as an active part of a scientific community, albeit at an amateur level. According to the authors, being able to experiment with technology, understand how it works, and its usefulness for scientific research, helps motivate students to use it continuously and independently, contributing to the construction of grassroots knowledge that goes beyond the school curriculum. In addition, students were able to see how their observations contributed to expanding the spatial and temporal monitoring of biodiversity, its relevance for a global view of patterns and trends, and as a basis for nature conservation

(Echeverria *et al.*, 2021). This second aspect concerns the scalability of problems relating to the environment, an issue that often takes a back seat despite being fundamental to the problem. More than other research, the use of Citizen Science creates the conditions in which a single piece of data, a small contribution collected at a local level, can be included and valued on a national or even international scale.

A study conducted in Canada through the implementation of BioBlitz and the use of iNaturalist to share the collected data, highlights both the value of taking part in initiatives defined as “real life,” and of “authentic” learning as it is experiential, conducted first-hand (Gass *et al.*, 2021). Furthermore, according to the author and the research team, working in a specific context through engaging and active learning fosters the development of what is defined as *a sense of place*. Semken and Freeman (2008, p. 1551) define sense of place within an educational context as the combination of place meaning, which represents knowledge about place learned through cognitive learning, and place attachment, which represents affective learning such as attitudes and preferences to place of learning. If we also refer to what was written by Ardoin (2006, op. cit. in Gass *et al.*, 2021, p. 1552) in the reflection cited here, who emphasizes that sense of place entails more than just the biophysical nature of place, but also integrates psychological, sociocultural, economic, and political facets, it emerges how biodiversity education, in working on the development of a sense of place, can contribute to the understanding of the multidimensional complexity we mentioned in reference to the definitions of biodiversity in the previous paragraphs.

To conclude, we briefly refer to the work of Schneiderhan-Opel and Bogner (2020) aimed at investigating the relationship between cognitive knowledge and environmental values. The authors propose a biodiversity education module designed to raise awareness about biodiversity loss among students and to engage them in biodiversity conservation. «Focusing on biodiversity conservation with the example of the forest ecosystem, the module involves students in a collaborative citizen science activity on DNA barcoding supplemented with educational materials and activities in the regular biology classroom» (Schneiderhan-Opel and Borger, 2020, p. 3). Among the results of this research, we believe it is useful to underline two aspects, the first concerns the fact that «even short-term education modules may effectively increase short-term as well as long-term knowledge on biodiversity and sensitize students to biodiversity conservation» (Ivi, p. 11). The second aspect concerns the data that «students with higher pro-environmental values benefit more from educational citizen science activities» (Ivi, p. 3).

Having explored the various research projects aimed at designing and implementing tools, methods, and pedagogical approaches to promote

biodiversity education, the next section explores the final research focus, namely, investigations that offer a meta-analysis of educational projects and programs for the protection and enhancement of biodiversity.

Systematic analysis of projects and intervention programmes

Publications that carry out a systematic analysis of Biodiversity Education or Biodiversity Conservation projects consist of publications of Jiménez *et al.*, (2014, 2015, 2017) referring to research conducted in Spain and Costa Rica, and a contribution from Ikin *et al.*, (2015), who propose a reflection starting from their ecological and social research in Southwest Australia. The research by Jiménez *et al.*, was based on the analysis of 85 CEPA (Communication, Education and Public Awareness and participation Actions) projects funded by the Spanish Biodiversity Foundation.

The research group also marks that the effectiveness of interventions is greater where the initiatives are designed ad hoc for a well-defined target. At the same time, in their early publication (Jiménez *et al.*, 2014) the authors highlight how the considered CEPA projects rarely address the involvement of minority groups. In their view, CEPA actions should identify the barriers to minority participation and develop strategies to overcome these barriers (e.g., Houghton *et al.*, 2002). The evaluation phase also appears to be lacking in the projects considered.

There are three focuses of interest in the educational processes aimed at biodiversity education that consider: «the quality of the teaching and learning experience, the importance of contextualized knowledge, and often attempts to promote informed decision making rather than attaining specific environmental outcomes» (Jiménez *et al.*, 2014, p. 832). Finally, it is useful to point out how «education actions often emphasized natural sciences as well, whereas human dimensions and general awareness related to biodiversity (e.g., climate change, urban ecology, consumption) were underrepresented» (Jiménez *et al.*, 2015, p. 68). The results obtained suggest that conventional educational and outreach approaches (i.e., dissemination of information and EE&C as an intrinsic value) will need to be transformed for their incorporation into biodiversity conservation projects that foster participation of multiple stakeholders in developing policy and implementing environmental management strategies (Evely *et al.*, 2011). This last passage highlights how interventions aimed at biodiversity education must be characterized as articulated proposals, starting from local contexts and mobilizing a variety of social and institutional actors to create

a complex network, active in promoting educational interventions, raising awareness and information, and activating policymakers. It is hoped that this network will intervene both at the micro level, involving various target groups (children, the general public, etc.), and at the meso level, through dialogue with local public administrations, the public and private stakeholders, to graft long-term proposals that can guide local policies. It is no coincidence that among the characteristics of CEPA actions deemed desirable, a pressing need emerges to focus at all levels on those identified as multipliers. Actors, due to their positioning, act as multipliers capable of activating processes that involve a significant number of people, both in the educational field (e.g., training teachers, who will work with class groups), in the social and political field (technicians and local administrators, who deal with entire communities) and in the economic field (small, medium, and large companies). The analysis carried out in Costa Rica in 2017 identifies a list of types of CEPA actions that are listed below:

- a. Environmental Education Center, a combination of educational initiatives and research
- b. Education for community-based management of natural resources
- c. Biological education with schoolchildren
- d. Environmental education with schoolchildren and community projects «aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution» (Stapp *et al.*, 1969, p. 30).

Ikin *et al.*, (2015) summarized their reflection in four key lessons: (1) effects of urbanization on wildlife extend into adjacent habitats; (2) strategic enhancement of the urban greenspace offers biodiversity gains; (3) large old trees need to be managed for long-term sustainability; (4) education and engagement connects residents with nature and raises awareness. Also, in this case, among the many reflections of the research group, it emerges that «public awareness and education about local biodiversity values can have a strong effect on how people perceive and interact with urban greenspace and adjacent reserve habitat» (Shanahan *et al.*, 2014, p. 211).

Conclusions

This brief excursus allows us to identify their articulation, highlighting the multiplicity of possible fields of investigation. Below we propose some considerations that have emerged from the literature, and are highlighted as potentially effective in promoting biodiversity education in relation to the

complexity inherent in understanding, conserving, enhancing, monitoring, and restoring biodiversity. Almost all the research focuses on how the interdisciplinary dimension is central. At the same time, studies show that there are, to a certain extent, marked hierarchies between disciplines. The issue of hierarchy, legitimacy, and power is also evident in other areas of knowledge production in biodiversity education: for instance, among those recognized as being entitled to produce knowledge rather than receive it, emerges the expertise mobilized in the process of research and data validation.

Furthermore, the countries of origin of the research, in many cases biodiversity hotspots invite a decentralization of perception to overcome Eurocentrism as the presumed privileged place for the production of knowledge. Similarly, it is highlighted how some academic terms and language can be perceived as distant from the contexts. In our view, pedagogical research for biodiversity can embrace the invitation to promote a multiversal approach; understood as an intentional and systematically pursued attitude to question hierarchies (Borghi, 2020), in all their forms. This entails not renouncing the responsibilities to which one is called, but rather assuming them fully within processes, in which the exercise of power itself becomes a practice of conscious decentralization. The heterogeneity of research clearly tells us that we need all possible efforts, the commitment of every person, everywhere. The perspectives of young individuals and adults is necessary; the contribution of the citizens and that of those who hold decision-making power at the political level. It is essential to enhance the school garden, as well as the vast protected area. The contribution of the teaching class, as well as the managerial class of large companies is indispensable. The contribution of the natural sciences, as well as the humanities and pedagogical sciences is also crucial. It is urgent to formulate proposals that promote experiential approaches in nature, place-based technologies that facilitate the circulation of data on a global scale. It therefore follows that it is important to systematically pursue a plurality of methods to support the plurality of relationships, at the micro, meso and macro levels.

In conclusion, we believe that there are new challenges for educational research on biodiversity that remain largely unexplored, or not yet sufficiently addressed. The first challenge concerns the *scalar nature of the environmental question* (Bougleux, 2017), mentioned above and often encountered in theoretical backgrounds in reference to the problems that characterise the environmental issue, but at the same time little explored from the point of view of pedagogical research for biodiversity. Some interesting points are raised on this topic by research that calls into question

the use of apps and Citizen Science initiatives, where these enable to the opening up of global scenarios owing to data sharing. While it is now widely accepted that building emotional relationships with natural contexts has positive effects on environmental awareness and can lead to changes in pro-environmental behavior, it remains to be seen whether and to what extent this approach triggers a positive increase in awareness of the implications of biodiversity on a non-local scale. Once again, a more articulated reflection on what this means and what the plans, contents and objectives of biodiversity education are in this regard.

The second challenge concerns a key element for increasing biodiversity: a reduced impact of human presence and activities on natural contexts. A question therefore arises that may seem bizarre ...is it possible to interpret biodiversity education not only in terms of knowledge, exploration, and experience of nature and the elements that inhabit it, be they plants or animals, but also with the aim of stimulating awareness of a *necessary absence*? Can biodiversity education foster awareness of absence, withdrawal, and stepping back? A sort of *pedagogy of subtraction*, through which we can experiment with taking a step back to make room.

At last, what in our view might be the most complex challenge for biodiversity education. Recent research conducted by Mammola *et al.*, (2023) shows that there are *cultural factors that influence biodiversity interventions at a social level*: the perception of usefulness and dangerousness of species act as driving force that influence, for instance, the willingness or attention to protect some species at the expense of others. This premise strongly challenges biodiversity education and related research, since one of the criteria sometimes used to define the natural or plant elements, around which to base research is the perceived closeness, familiarity, and sometimes even sympathy on the part of the human subjects involved. It is possible to promote an education for biodiversity, that not only protects against the risk of reinforcing these biases, but above all that contributes to mitigating them.

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Part 2

Methodological approaches

Toward an ecosemiosis of common becoming. Educational scenarios inspired by ecological diversity

by *Andrea Galimberti*

Expanding the horizon beyond anthropocentrism

The “intrusion of Gaia” into public debate and into an increasingly widespread collective perception creates the need and urgency to respond to epistemological, ontological, and ethical-political disorientation, particularly in relation to the positioning of humans in the Anthropocene. This is an epochal challenge in the face of which we must first and foremost «resist the temptation to reduce to a simple “problem” that which makes an event, that which questions us» (Stengers, 2021, p. 66).

The “geological proportions” of human actions create an unprecedented scenario that leads to the search for new ways of interpreting reality. Morton (2018b), for example, defines global warming, ocean acidification, biodiversity loss, and the “sixth mass extinction” not in terms of natural “catastrophes” but as “hyperobjects”. Hyperobjects are “omnipresent planetary entities” and are “viscous”: «run away to any point on earth and they will stick to you and never leave you» (*Ivi*, p. 70); we are inside them «like Jonah in the belly of the whale» (*Ivi*, p. 34). At the same time, they are “non-local,” that is, widely distributed in space and on time scales that are immeasurable to us, so they “retract,” meaning we can only experience them in fragments (they follow a sort of Lacanian “*extimité*”, they are intimate and distant); it is a matter of “extended finitude” that «forces humans to live with a strange future, a future without us» (*Ivi*, p. 125).

Educating in the age of “hyperobjects” implies the need to «reconsider the fundamental ideas we have formed about what it means to exist, what the Earth is, what society is» (*Ivi*, p. 28); a task which, for pedagogy, is not limited to raising awareness and sensitivity about the seriousness of the current eco-climatic crisis, but requires a revision of its own paradigms and models of development, for example in reference to a long tradition that sees

education as extraction from the “realm of animality” (Reboul, 1997, p. 24) or in relation to forms of anthropo-logo-centrism underlying certain discursive formations and linked to a certain “myth of omniscience” (Ceruti, 2018; Cambi and Pinto Minerva, 2023).

Paraphrasing Latour (2019), we could say that new questions arise if we travel from “humans in nature” to “*anthropos* in the Anthropocene”.

Various ecological perspectives re-thematize the relationship between “human subjectivity and otherness,” seeking to identify emerging equilibriums and new possible forms; however, it appears extremely difficult to emancipate ourselves from the dualisms we have inherited. Above all, the one that divides the relationship between nature and culture and has led us to describe the former as “close and foreign”; but more broadly, as Agamben points out, to consider a social sphere in which non-human life (*zoé*) is «that on whose exclusion the polis is founded, or, more precisely, that which is included in it through its exclusion and, in this way, serves as its negative foundation of politics»¹. We are still part of a *polis* that is founded “negatively” on distancing itself from a “non-human” that is left outside the sphere of coexistence. Of the same nature, but in the opposite direction, are positions that today risk proposing a reductionist “naturalism” paradoxically constructed on the same divisions of an anthropocentric logic. Chiurazzi (2021), for example, shows two trends in this sense.

- A “naturalism by elimination” where the disappearance of *anthropos* from the center of cosmogony aims to restore the dominance of a nature that no longer has any human character. Latour (2019) spoke in this sense of a sort of “physismorphisation” of living entities, which consists in giving them the form of objects defined only by their causal antecedents.
- A “naturalism by expropriation”, or an extension of the specificities of the human that are assigned to nature; these are processes of undue anthropomorphisation: «if humans have no privilege in creation, if they cannot claim any exceptional character, it is because nature is already endowed with the characteristics that they claim exclusively» (Chiurazzi, 2021, p. 9).

How, then, should we go about finding ways to decentralize the human without disqualifying him or denying his characteristics, highlighting the connection with non-human otherness, but at the same time recognizing differences and thresholds of discontinuity? These are fundamental critical issues and dilemmas to be addressed with regard to the possibility of centering pedagogy on a “common world” of which the entire ecosphere is a part. Recent reflections (Oliverio, 2024) are taking shape on this front,

¹ <https://www.doppiozero.com/giorgio-agamben-le-anarchie-del-potere>.

aimed at extending Biesta's (2021) "world-centered education", inspired by Arendtian motifs – and therefore based on the possibility of "coming into the world" by manifesting one's subjectivity – to those whom Donna Haraway (2016) calls our "ontologically heterogeneous companions". This proposal is in some ways similar to the document drafted by the Common World Research Collective (2020), *Learning to become with the world: Education for future survival*, and formulated as part of the UNESCO initiative *Futures of Education: Learning to Become*, a global debate on how to reimagine education and learning in a world of increasing complexity, uncertainty, and precariousness. The document, which takes the form of a veritable manifesto, bases its argument on the need to shift the focus of educational reflection from the urgency of identifying effective ways of acting "on the world" to the ability to learn to "become with the world". In this direction, a profound revision of the premises that base the exceptional nature of humans on their separation from the rest of living beings is proposed, following Haraway's calls for the need to thematize "natureculture" in a broad, plural and differentiated sense. In summary, we could say that two fundamental questions continually echo in this stream of reflections: "What position for *anthropos*?" and "What world in common?".

Communicating biodiversity: the risks of a reductionist and instructive approach

These assumptions influence the way we "talk about ecology" (Morton, 2018a) and how we conceive of "being part of" complex systems (Galimberti, 2024). Promoting ecologically responsible behavior, understood as the development of perceptive attitudes and dispositions to act, cannot be separated from a broader vision in which we inscribe the eco-climatic crisis. It is, in fact, profoundly different to move in a simple (albeit dramatic) "background" on which we will have to act or "feel" the "hyperobjects" of which we are a part and which cast a disturbing shadow on our ability to separate the human from the non-human².

² In documents that guide educational policies at the international level, we find, for example, the first perspective widely disseminated: «However, on closer inspection, this is a naive, if not downright biased, conception of ecology, still too dangerously anchored to a superficial approach typical of the Anthropocene, which wants ecology to deal primarily with the environment as "surroundings" and considered for its use value. This would explain, in part, the widespread feeling that today we can recognize as ecologically responsible the occasional adoption of behaviors almost exclusively oriented toward environmental protection» (Giunta, 2023, p. 261).

In the *Educating for Biodiversity* project, which aimed to experiment with innovative methodological approaches and educational tools designed to raise awareness of biodiversity, it was necessary to take a position on these issues, outlining horizons of meaning and guiding a series of theoretical and operational choices.

The initiative was developed by a group of educators from the Department of Human Sciences for Education “R. Massa” at the University of Milan-Bicocca³ through ongoing dialogue with colleagues who are biologists at the same university within the *National Biodiversity Future Center*⁴. In particular, the working group was involved in Spoke 7, which aimed to develop new modes of communication and teaching, and this led to the need to question certain assumptions about communication and the implications in terms of modeling and designing educational settings.

For example, the national center clearly and decisively affirms the idea that “biodiversity is the solution,” i.e., that protecting the multifaceted variety of life is one of the best strategies for limiting the catastrophic consequences of human impact on ecosystems. Therefore, from the outset, educational activities capable of conveying this message were envisaged. In the face of denialist narratives, the desire to disseminate accurate scientific data widely and to all age groups of the population is entirely understandable; data that irrefutably demonstrate how human action is profoundly undermining the ability of the entire ecosystem to regenerate its own balance (Casiraghi, 2023). The fact that we are destroying biodiversity, however, is not a simple neutral observation that we simply want to “report”: in other words, we are moving from “*matters of fact*” to “*matters of concern*” (Latour, 2010), meaning that we are no longer faced with a “constatative” statement (which science constructs and validates through its own method), but with a “performative” statement that calls for action. Hence the expectation of being able to directly influence “ecologically responsible” behavior and, why not, the very identity of individuals. On the other hand, in perfect coherence with this representation, recent studies on “*environmental self identity*” show that

³ The BEAT (Biodiversity Education and Awareness Team) research group is based in the Department of Human Sciences for Education “R. Massa” and addresses biodiversity through a variety of languages and practices with the aim of outlining education and training initiatives for biodiversity.

⁴ The National Biodiversity Future Center, funded by PNRR funds, aims to promote a closer and more systemic relationship between science and society in order to understand and protect biodiversity. Spoke 7’s vision, in particular, focuses on developing new ways of communicating and teaching, aiming for concrete and measurable impacts, and integrating biodiversity research with policy makers, public and private institutions, and stakeholders. The goal is to create effective, evidence-based policies to preserve biodiversity in a sustainable way (<https://www.nbfc.it/>).

when environmental awareness becomes central to the idea of self, proactive actions on this front increase (Udall *et al.*, 2020).

From a pedagogical point of view, however, some fundamental critical issues emerge, connected to the assumptions we briefly highlighted above. First of all, there is the risk that the urgency dictated by matters of concern will lead exclusively to a focus on the preparation of understandable content and its dissemination through linear and instructional approaches, based on the idea of a predefined message to be “transmitted” (Wildemeersch, Håkansson, and Læssøe, 2023), thus neglecting the form of the educational contexts in which they are conveyed. This underestimates the complex ecological interweaving of additional messages that unfold on multiple contextual levels and generates what Bateson called deutero-learning (Galimberti, 2024), which manifests itself in the relational patterns we acquire while learning the specific content we intend to convey (in this case, biodiversity). In short, focusing on pre-prepared content in order to make it “understandable” risks diverting our attention from the messages we inevitably convey about the type of relationship we establish with biodiversity (is it an “out there” backdrop on which we can act, or does it play out in an “intimate and distant” dimension?). This “leap in level” marks the difference between devoting oneself exclusively to the search for effective tools to convey predefined information and questioning the actual possibility of structuring experiential fields of a “hyperobject” (Morton, 2018b) which – precisely in order to combine intimacy and distance – requires decisive pedagogical creativity.

Finally, there is the long-standing question of discipline, which is a fundamental part of educational practices (Massa, 1987) and which risks becoming predominant when, with the best of intentions, we set out to “discipline” or “enlighten” those who have not understood, forgetting that «authentic pedagogical competence requires the ability to communicate by shifting one’s point of view in order to encounter the other, without pretending to incorporate them into one’s own universe of meaning» (Dozza, 2009, p. 239).

Getting out of some of these *impasses* meant moving in different directions and making a real epistemological shift, observing, for example, how the idea of communication that had been taken for granted (but which later proved to be based on hierarchical, linear, and decidedly logocentric assumptions) was not consistent with the subject we wanted to discuss – in other words, it was not very “biodiverse.”

Biosemiotics, ecosemiotics, and systemic thinking

The project sought to focus on the field of communication not simply as a *medium*, but as a place for exploring and experimenting with the need to overcome the division between nature and culture, repositioning *anthropos* in a radically relational scenario that is not structured on an ontological hierarchy. In this regard, it was useful to shift from the field of communication to that of semiotics.

Semiotics is known as the discipline that deals with the social and cultural dimension of meaning and investigates «the human being as an animal that interprets the world» (Eco, 2009), but since the 1990s, it has developed a series of variants that have gone beyond a vision strictly linked to culture and language:

Semiotics has had to legitimize its existence and the effectiveness of its tools based on two fundamental questions that it had previously rarely asked itself: the question of the origin of the semiotic processes it investigates and the question of the cognitive processes that allow such investigation (Lobaccaro, 2025, p. 39).

One of the variants that have sprung from this intra-disciplinary reflection is biosemiotics, which extends the semiotic field to all living things, asserting that “life and semiosis are coextensive” (Sebeok, 1991), thus moving «from an anthropocentric cultural level to a biocentric level» (Iovino, 2015, p. 105). Biosemiotics is divided into several branches (zoosemiotics, phytosemiotics, cytosemiotics, etc.) and its fundamental questions are aimed at investigating how organisms interpret and respond to signs that they decode in their environment (Faverau, 2010).

In reality, this theoretical position is deeply consistent with the assumptions of one of the fathers of semiotics, Charles Sanders Peirce. His vision, already in the late nineteenth century, was fundamentally inspired by “pansemioticism”, or the idea that there is a semiotic continuity articulated in different ways of making and interpreting signs, whose heterogeneity can be read as a differentiation of a single continuous fabric (Kull, 2018). Peirce proposed a non-logocentric semiotics, and his concept of signs is considered from a trans-specific, non-anthropocentric perspective (Fadda, 2019; Kull, 2024).

This is a perspective that, in some ways, has strong continuities with systemic thinking and complexity studies, more precisely in relation to the conception of a world of information as not only human (Brier, 1996). Morin, for example, identified in the act of “computing”, understood as the ability to draw distinctions, select, connect, compare and evaluate, a dimension that

runs through the history of life on earth: «the humblest of cellular beings is capable of fully computing its own organisation and the data of its external environment» (Morin, 2004, p. 186).

Long before the history of life brought forth a speaking species, endowed with consciousness, capable, several millennia later, of linguistically proclaiming the proud *cogito ergo sum* – long before, we said, countless living beings, devoid of consciousness and for the most part devoid of brains, were perfectly capable of announcing, through vital actions and operations, their silent, uninterrupted, *computare ergo sum* (Manghi, 2009, p. 75).

The resonance with the words of two biosemioticians are evident: «the world is rich in systems sophisticated enough to be able to respond to selected differences» (Hoffmeyer and Emmeche, 1991, p. 123).

But it is Bateson and Peirce who are united by a deep connection, particularly in relation to the concept of “Mind” (Hoffmeyer, 2008). The ecology of mind proposed by Bateson (1976), in fact, outlines an immanent process structured on communication channels that do not coincide with the boundaries of the individual entity, but go beyond them, and where the connected perceptual apparatus can perceive differences and recode them (the famous definition of information as “difference that makes a difference”). For Peirce, the mind consists of the structure of the triadic transaction between object, sign, and interpretant, where “interpretant” is not to be understood as a human subject, but as an interpretative activity capable of making inferences. Peirce's mind is an operational capacity; in fact, it is a sign device that relates “map” and “territory” (Kull, 2024). The two authors share a vision in which «human thought is not the yardstick and measure of all possible intelligence – on the contrary, precisely because it is part of intelligence in general, it is a manifestation of the mind (strictly in the singular)» (Fadda, 2019, p. 36). The theoretical similarities are many and obvious, but for the purposes of this paper, one point in particular should be emphasized: both propose the idea that semiotic activity has to do with patterns, i.e., with regularities due to morphological and sensorimotor aspects that lead to perceiving and modeling the environment in a certain way (signs are always embodied and enacted, see Fields and Levin, 2020) and with dynamic interactive structures that create repeated relationships between living beings and their environments (“the structure that connects”). The aesthetic dimension, or the “form” of these patterns, is at the forefront.

These intertwining threads of biosemiotics, systemic thinking, and complexity theories find an explicit connection in the perspective of ecosemiotics, which aims to investigate the co-evolution between biosemiotic activity and ecological systems (Maran, 2021; Zengiaro, 2025), i.e., the encounter between environmental conditions and organisms capable

of selecting their own possibilities for action. These are co-generative processes that always involve a form of interpretation, i.e., in which distinctions are activated that presuppose the ability to establish salience and relevance between signs and consequent decisions (true sense-making). This leads to a renewed idea of *Umwelt* (von Uexküll, 2015), or the perceptual and operational world of a given organism, in terms of a “semiotic space of experience”:

Once we recognize that all complex systems, in biology, culture, and society, are characterized by a common similarity (iteration) given by nature’s parsimony in developing *patterns*, it makes perfect sense that both an organism’s particular environment (*Umwelt*) constitutes its semiotic space of experience (semiotic niche), limited only by the needs of its species, and that the evolution of life can be understood as the history of the emergence of increasing levels of semiotic complexity – or, as Hoffmeyer defined it, “semiotic freedom” (Wheeler, 2005, p. 28).

Therefore, human culture – which maintains its peculiarities inseparable from the uniqueness of linguistic experience – represents one of the *Umwelten* present in a larger ecosemiosphere, in which it is possible to speak of interspecies dialogue and semiotic engagements within “ecological relationalities” (Hayles, 2025) and where there are a plurality of agents who, in order to develop cognitive and interactive patterns, «do not need to be conscious [...] they need to be structured to exploit physical regularities that allow them to use information to perform their vital tasks» (Levin and Dennet, 2020, p. 5). Nature, therefore, «is not mere extended matter, but living matter permeated by thought, that thought of which human thinking is but an epiphenomenon» (Mortari, 2020, p. VIII).

This view strongly contrasts with the mistaken belief that only humans (and perhaps a few other mammals) are capable of constructing meaning, opening up the entire biosphere, both in its conscious and unconscious spheres, to the intertwining, overlapping, mutual reinforcement, or contestation of areas of meaning (Hayles, 2025, p. 109).

Educational experiments in an ecosemiotic framework

The in-depth study of the theoretical frameworks proposed by biosemiotics and ecosemiotics has made it possible to approach the topic of “communication” in a new way, transforming it from a “tool” to an element common to all living beings, albeit with different characteristics. This has

led to the emergence of a potential experiential field in which to experiment with the closeness/distance generated by encounters with biodiversity.

These considerations were the starting point for a nationwide experiment, still ongoing, involving children, young people, and adults in different Italian regions (Persico, Guerra, and Galimberti, 2024). We have gradually outlined an experiential, research-based, and place-based approach, in line with some national and international experiences (Navarro-Perez and Tidball, 2012; Birbes, 2017; Cagol and Dozza, 2018; Guerra, 2020; Strongoli, 2021; Antonietti *et al.*, 2022; Blenkinsop and Kuchta, 2024; D'Aprile and Bufalino, 2024). In particular, to remain consistent with the assumptions outlined above, we have distanced ourselves from an exclusively “custodial” approach to nature “out there”, focused on predefined scientific explanations, in order to propose a search for a plurality of “natures”, understood as the multifaceted coexistence of different spaces of semiotic experience in interaction.

The place to be explored is therefore proposed as a shared world that is inhabited in a pluralistic way and is loaded with “natural-cultural” semiotic virtualities: the multisensory sphere of the participants is thus engaged in order to grasp signs (by observing, listening, touching, smelling) of the material “traces” of the biodiversity present (what Peirce calls “index” – the sign as physical contiguity with the object). A shared world that is always perceived in a partial way: «the traditional object of semiotics, the sign, derives from a selection. To mark is to sign and to be able to perceive certain signs and not others» (Leone, 2019, p. 9); thus, the aspects that strike one's attention and those that orient others in a differentiation that is part of the ecosemiotic dynamic become visible: the «discontinuity for Peirce always emerges from the arrangement of a continuum» (Fabbrichesi, 2014, p. 31).

At the same time, invitations are extended to search for patterns, the “infinite beautiful forms” (Carroll, 2011) of the relationship between living beings and the environment, with the idea that learning to see, to “awaken a sense of wonder” (Cagol, 2023), is to learn to trace connections and distinguish “forms,” and that all living things do nothing else (at this point, we are close to what Peirce calls the iconic dimension of the sign – structured on abductive processes that capture redundancies and similarities).

There are also explicitly reflective engagements (and here we arrive at language, and therefore at the symbolic dimension of the sign), such as the request to develop processes of hypothesising; for example, when we encounter boundaries that prevent us from experiencing otherness. That is,

when what we relate to “withdraws” and we are unable to understand its *Umwelt* of reference⁵:

We are only able to perceive a limited amount of sounds emitted by a vibrating string. We are only able to see a very limited section of the electromagnetic spectrum. We know that sounds and lights tower over our perceptual realm with their unattainable depths and heights. What we savor is the metaphorical – yet vivid – taste of the fact that all entities are deeply withdrawn (Morton, 2018b, p. 220).

The presence of experts in naturalistic disciplines (biologists, ecologists, geologists, etc.) was envisaged at this point in the process, in order to better explore the semiotic analogy/difference on the basis of structural homologies and adaptive convergences – with the idea of not ending the research with explanations that close off curiosity, but of relaunching the process towards further openness. This choice meant working with colleagues from other disciplines on the ability to remain open to the semiotic possibilities emerging from the explorations and not to worry exclusively about transmitting “correct” maps. Unexpected questions such as “why do bricks attract larvae?” become, in fact, interesting opportunities to grasp the relationship that has been hypothesised between *Umwelt* and organism and to follow the wealth of meanings that this track brings with it. Finally, a meta-reflective dimension is also encouraged through the request to dwell on the pattern in which one is participating, i.e., on one's personal relationship with the biodiversity of that specific place and on the interaction with “ontologically heterogeneous companions” (Haraway, 2016) who are present, thus highlighting one's own biographical trace within the exploration (Thevenot, 2025). Thanks to national experimentation, which currently involves fifty educational institutions in eight regions with which we have maintained continuous dialogue (monthly meetings) and training sessions (a dedicated Fall school), we have refined a methodology, mediators (Palmieri, 2018), and tools (Guerra, 2024). A series of proposals have thus been developed that open up exploratory possibilities in the name of decentralization and the possibility of broadening one's point of view, following continuous changes in perspective, to move away from the posture

⁵ On this difficulty, one cannot help but refer to Nagel's famous essay “What is it like to be a bat?” (2024): «It will not help to try to imagine having a membrane between our fingers that allows us to fly at dusk and dawn, catching insects with our mouths; nor will it help to imagine having very poor vision and perceiving the world around us through a system based on reflections of high-frequency sound signals; nor will it help to imagine spending all day hanging upside down in an attic. To the (limited) extent that I can imagine all this, what I imagine only tells me what it would be like for me to behave like a bat. But that is not the point. What I want to know is what it is like for a bat to be a bat» (pp. 26-27).

of those who explore nature “from the outside.” Thus, a series of open invitations in different directions (“actions,” “perspectives,” “questions”) that are not organized in predefined linear sequences, but offer often surprising combinations along a chaotic and creative process that is potentially infinite (consistent with Peirce’s idea of unlimited semiosis).

There are many educational strategies designed to offer such an experiential field; I will mention just a few (for further information, see Guerra, *infra*). The choice to maintain a certain semantic vagueness in the elements to be explored (using terms such as “traces,” “carcasses,” and “environment”) that can be interpreted in multiple ways along axes of difference/similarity and attributed to both the human and the non-human. The possibility of using tools (some common, such as magnifying glasses, others more unusual, such as stethoscopes) that become, on the one hand, “amplifiers of disorientation” and, on the other, resources for finding new “signs” to interrogate. The use of naturalistic notebooks for documentation (Guerra and Luini, 2024) as an indispensable element for making the patterns of exploration materially visible, maintaining a common thread within the multiple stimuli encountered, and observing one’s own particular way of becoming involved.

Conclusions: rebuilding a shared world

In the strange place where we have been dragged by “hyperobjects” such as global warming or the loss of biodiversity, “knowledge is no longer able to reach the escape velocity of the earth” (Morton, 2018b, p. 205) and the asymmetry between action and reflection can generate a strong sense of unease and paralysis. Such complexity can no longer be resolved simply with a vision that points to a Nature “out there” to be safeguarded and protected, but rather requires us to explore and formulate more “biodiverse” visions, i.e., visions oriented towards considering and thematizing a plurality of natures along a continuum rich in multiple differentiations; in which humans can see their own unique characteristics recognized, but at the same time recognize the resonance and deep connections with all living things.

Contrary to what a superficial reading might suggest, the term “Anthropocene” does not mean the great superior fusion of a unified “nature” with a unified humanity [...] but rather the astonishing fragmentation and dissemination of the entities that compose it (Latour, 2019, p. 163).

To prevent this diversity from resulting in risky fragmentation, there is a need to support an attitude of continuous re-composition of common worlds, in which humans and non-humans can experience renewed forms of encounter, dialogue, and discovery. Therefore, still following Latour, «it is necessary to redo politics all over again – by “politics” I always mean, of course, the progressive composition of a common world» (*Ibid.*).

This work of continuous weaving implies distancing oneself from an exclusively instrumental view of knowledge and seeking ways to develop a renewed aesthetic perception of the bond (Todd, 2022; Varpanen *et al.*, 2024): «aesthetic experience is not about givenness [...] aesthetic experience is about solidarity with what is given» (Morton, 2018a, p. 111). This shift presupposes «a radical shift from the logic of controlling formative processes [...] to the logic of caring that preserves and cultivates the differences in thought and feeling of educational subjects» (Mortari, 2020, p. 175). It therefore means developing *formae mentis* capable of addressing the challenges posed by the Anthropocene not only in terms of critical thinking, but also in relation to the ability (always individual, but not solipsistic) to “feel” connections with living beings in a broad sense. Faced with this need, it is not enough to set up educational scenarios exclusively dedicated to transmitting information; it is also essential to thematize a form consistent with the relational patterns that we intend to propose. In this case, a form consistent with what we mean (ontologically, epistemologically, ethically) when we invite people to “encounter biodiversity”.

A new pedagogical creativity is taking shape on this front, both at the theoretical level and in the experimentation of educational practices, and the dialogue with biosemiotics and ecosemiotics appears, in this sense, generative and full of possible future developments.

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An ecological approach to educating about, in, and for biodiversity

by *Monica Guerra*

Education and biodiversity

The BEAT – *Biodiversity Education and Awareness Team* research group explores and discusses biodiversity through language and pedagogical practices in order to outline educational and training activities within an experiential ecological perspective. As part of the work initiated with NBFC – National Biodiversity Future Center and developed in the Department of Human Sciences for Education “Riccardo Massa” at the University of Milan-Bicocca, it has theoretically and methodologically defined an approach to education for biodiversity, in a continuous dialogue between the emerging reflection from scientific literature on ecological, place-based, and *outdoor* education and *biodiversity* education, and the elements gathered from empirical research conducted in formal, non-formal, and informal contexts with people and groups of different ages and backgrounds (Persico, Guerra, and Galimberti, 2024).

If biodiversity, or biological diversity, concerns the variety of life in all its forms, levels, and combinations – including genetic diversity, species diversity, and ecosystem diversity, the ecological roles played by organisms, their interactions, and their interaction with the environment they inhabit – it presents itself as a complex system of relationships present in everyday life contexts.

Starting from this point, educating for biodiversity can only require a contextual approach that is always different and, by its very nature, site-specific, just as heterogeneous subjects require experiences consistent with their characteristics, resources, intelligence, and questions: the approach developed, therefore, has chosen to identify certain categories that can be tested across the board, regardless of the places and recipients involved, but at the same time can dialogue with their specific characteristics.

In this sense, it is a proposal that, without any claim to be exhaustive, can be interpreted in a variety of ways by those who use it, depending on the people or groups it is aimed at and the places with which it interacts. This clearly distances it from proposals structured around predefined activities, requiring instead active interpretation by those who accompany it, while at the same time aiming to respond in the most contextual way possible in each situation.

Consistently, it is not so much proposed as a teaching model, but rather as a set of methodological considerations that can support meaningful experiences in dialogue with the environment, aimed at promoting the development of greater curiosity first and then awareness about the world and its biodiversity.

The reference framework for the approach and tools that are taking shape can be summarized as experiential (Dewey, 1938) and exploratory (Guerra, 2019) action, particularly consistent with forms of education that find their ideal context outdoors: in this vein, exploration can represent a specific, often initial, moment of the experience, but it is even more interesting to understand it as a particular way of proceeding, identified first and foremost with moments of direct and sensitive encounter with natural matter (Guerra, 2023). Such moments are characterized by freedom of action and movement, choice and involvement, with repercussions in terms of experimentation, resourcefulness, participation and, more generally, respect and appreciation of individual characteristics, resources, interests, needs, questions, and skills (*Ibid.*).

This type of approach appears particularly consistent with an educational perspective for ecological and place-based biodiversity: ecological in that it intercepts the relationship with places as a qualifying dimension and is oriented towards capturing and promoting connections and reciprocity between individuals and the world; place-based because it is based on the connection with the local and contextual dimension of the environment, the territory, and the community, as well as on the experiential nature of the proposals (Guerra, 2024).

In this perspective, despite the articulation of reference theories and practices, the development of an ecological attitude is achieved first and foremost through involvement with the world and the life that inhabits it, in the possibility of experiencing experimentation in a direct, continuous, and personal encounter. A direct and constant relationship with the world, in fact, contributes to developing a greater sense of connection, belonging, and therefore ecological awareness, training the eye to recognize the biodiversity around us and fueling the desire to experiment with more sustainable behaviors (Judson, 2017, 2019; Mortari, 2020).

In this approach, the investigative dimension of the experience, embodied by a shared research posture between those who accompany and those who are accompanied, expressed through the privileged form of questioning, and the documentary dimension of the reconstruction and reworking of the process, fundamental in outdoor experiences typically characterized by openness, fluidity, and unpredictability, constitute two other central nodes to be explored in detail (see below, Persico and Luini).

The proposal outlined above can be summarized through the articulation of five categories, which allow the environment to be explored through multiple keys of access and interpretation, themed as actions, elements, tools, positions, and questions. Each of these categories is broken down into a series of possibilities, already tested with a large number of educators and teachers.

Every individual proposal in each category constitutes what we might call an invitation to experience or even a trigger for research, with an implicit question aimed at focusing attention: in this sense, each one is intended to be a guideline, without however seeking to guide or, above all, force the direction or manner in which observations and investigations are carried out in the environment. For this reason, too, each invitation is deliberately exposed to a high level of interpretability, as is typical of any open question: it is precisely this characteristic that contributes to making the experience particularly inclusive, as it allows each person to interpret it according to their own resources and interests, in dialogue with the affordances (Gibson, 1979; Kyttä, 2002, 2004; Waters, 2017; Guerra, 2022) made available by the environment and its constituent elements.

At the same time, each suggestion is also an invitation for those accompanying the experience to explain their educational and didactic choices, making the reasons for them clear: each step, from the first to the subsequent ones, requires a position to be taken, a direction to be chosen – or even the delegation of the choice of the next direction – inviting recognition of the design decisions as they unfold.

Below, we will explore the five categories, which, according to the research group, represent the creation of a flexible yet rigorous methodology for traversing and accompanying encounters with an environment and its characteristic biodiversity.

Actions

The scope of action is the starting point for exploratory research. Exploring can be understood primarily as the movement aimed at discovering and learning about something that is unknown, but also something that is only

partially known or, in relation to biodiversity, something that we wish to re-discover, offering it our careful and dedicated attention.

Often associated with inquiry and investigation, exploration represents a mode of research that takes place in an experiential, concrete, material encounter with the object of interest and which, likely for this reason, appears recurrently in the context of those heterogeneous practices that take place outdoors (Guerra, 2023), in places, in the environment, in the world. In the approach taken here, as anticipated, exploration is a privileged way of understanding all educational planning, therefore including every action, time, and manner. At the same time, it is also the initial invitation to encounter a place by dedicating oneself and taking the time to settle in and become familiarized with the space without specific requests: if this allows for an initial acquaintance, it also facilitates the emergence of specific interests of the different subjects, immediately revealing the attitudes and curiosities of each of the people involved, a fundamental aspect for evaluating the actions and choices to follow.

For these reasons, the proposal outlined here suggests an initial entry into the environment to be explored through an invitation to initially perform broad actions, such as orienting oneself by seeking out what most attracts each person, in order to allow personal strategies and focuses to emerge. In the initial stages, but also in the subsequent stages in a recursive manner, in addition to this type of action, other more sensory actions, which involve the activation of the body as well as the mind, allow the subjects to relate immediately and directly to the environment: among these, we mention here, by way of example, the act of observing, listening, or touching. A subsequent set consists of actions that encourage the integration and organization of initial knowledge, explicitly introducing a more reflective dimension, such as describing, connecting, and hypothesizing. Obviously, each action is not limited to a single moment in time – and even less so to a single phase – but recurs continuously throughout the research process: the proposed actions develop according to a principle of circularity and, even more so, of contemporaneity, showing that they cannot be isolated from one another. However, inviting them to focus on them individually, giving priority to one or the other from time to time, while on the one hand constituting an obvious reduction in complexity, on the other allows them to highlight, experiment with, and recognize their specificities, noticing the different types of knowledge they elicit and, at the same time, the different modes of investigation they suggest. In addition, the explicit and intentional provision of a variety of actions useful for investigating a situation and, specifically, an environment, is a statement by those who accompany and educate on the value of each way of proceeding and, therefore, of each resource, while at

the same time allowing them to recognize the different intelligences and styles of all the subjects accompanied.

In this sense, the reduction that takes place on the one hand offers the opportunity to grasp the articulation of strategies, possibilities, and movements present on the other within a group in relation to the same environment, which is thus fully explored in all its variety and complexity.

Elements (and environments)

The place where an educational experience takes place is never neutral, as it shapes the dimensions, times, relationships, meanings, and learning itself.

Educating about, in, and for biodiversity, as is obvious, but also in line with the guidelines provided by place-based education, finds its ideal setting outdoors, where it can literally become living matter. Outdoor education (Donaldson and Donaldson, 1958; Humberstone, Prince, and Henderson, 2016), also understood as a pedagogical practice aimed at promoting learning through direct experience in natural contexts, is certainly a privileged setting for biodiversity education.

This shift in focus is also a way of making room for a more experiential form of education, which can certainly also be experienced indoors, as many practices show, but where it requires the breaking of a greater number of constraints and rigidities. In indoor spaces, in fact, mechanisms of control, surveillance, and transmission of knowledge (Foucault, 1975; Antonacci and Guerra, 2018) are historically more consolidated; outdoors, on the other hand, situated learning (Lave and Wenger, 1991) and experiential learning (Dewey, 1938; Kolb, 1984) have been promoted more, aimed at enhancing, on the one hand, the activation of people in training and, on the other, the reciprocal relationship with the environment.

It is not, therefore, a question of opposing “indoor” education to “outdoor” education – an opposition that is the result of a distinction that should be overcome in favor of an organic experience that takes both dimensions into account and is capable of integrating different spaces and knowledge – nor is it just a question of physical displacement, which in itself is never neutral: rather, it means first conceiving and then implementing different ways of inhabiting the relationship between subjects, environments, and knowledge, with obvious epistemological, pedagogical, and symbolic implications (Guerra, 2020).

In this sense, biodiversity education, as outlined here, aims to promote a comprehensive restructuring of the educational proposal from an ecological perspective (Persico, Guerra, and Galimberti, 2024), starting from questioning

how and where we learn about the complexity of living things, ecological interconnections, and our place and role in the world. Moving outside, into the environment and ecosystems that can be explored, allows us to encounter the systemic complexity of biodiversity within the network of ecological relationships, recognizing ourselves as part of it and not as something separate from it, ultimately encouraging greater involvement with living things, which is more difficult to experience within educational practices where knowledge risks being decontextualized and only conceptualized.

The outside world, therefore, is the priority context here, free from contrasts but consistent with the reasons and objectives of an educational practice interested in the experience of biodiversity.

Given the environment, which can only be considered in its specificity and particularity but which, methodologically, requires interpretation through certain core elements that are as recognizable as possible in every context, it is a matter of selecting certain elements to investigate more precisely. In this sense, proposing elements within an environment means isolating them from the system to which they belong in order to see them better and investigate them more thoroughly. However, experience quickly shows that this is also an exercise in simplification and reduction of complexity, which becomes evident when, precisely by deepening our knowledge of a subject, its many relationships with all the others gradually emerge.

From the point of view of biodiversity education, each element (for example, among those selected, mammals, birds, insects, fish, leaves, flowers, fruits, seeds, mushrooms, stones...) allows us to grasp the variety of life not only in the expression of different species, but also within each one, and at the same time, by exploring them individually, we can understand the role of each within the environment, such as the combinations and relationships with others and with the environment itself. Focusing on a single subject is therefore a useful, albeit artificial, exercise, not least because it allows us to quickly grasp, as we proceed, the limitations and paradoxes of such separation, enabling a better understanding of individual aspects and, at the same time, of everything that connects them to something beyond themselves. Read in this way – i.e., not limited to hyper-specialization on a single element – in-depth investigation of a single subject soon reveals other meanings. Furthermore, the implementation of a rigorous research process, while proposing to devote oneself to targeted observation, offers the possibility of experimenting with a methodology that can be applied extensively to other subjects and environments.

At the same time, the experience of a method reduces the risk of exceeding quantitative limits in terms of content, in favor of a conscious, participatory, and involved in-depth analysis.

Tools

In the exploratory approach, research may require or be enriched by the inclusion of tools that represent appropriate means for development and in-depth analysis. In this sense, during the experience, it may be interesting to integrate tools that are consistent with both the strategies implemented by the people involved and the ongoing investigations and emerging questions. Alongside collection or measurement tools, particular attention will be paid here to the role that tools, albeit heterogeneous in nature, can play in supporting observation, particularly in line with the approach presented here.

Observation tools, in fact, are not only technical aids to complement the experience, but also true epistemological, educational, and didactic focalizers and mediators that can facilitate and articulate access to a situated, complex, and multidimensional knowledge of the ecosystem under investigation (Guerra, 2024). The act of observing, together with the tools that support it, contributes significantly to developing a participatory and conscious relationship with living beings, based on an organic process of perception, interpretation, and reflection.

Observation tools in biodiversity education, therefore, are not simply devices for detection or cataloging, although these are certainly present and relevant, but constitute interfaces that facilitate a dialectical and situated relationship between the subject and the environment (Lave and Wenger, 1991). Through these tools, those who observe an environment can access levels of complexity that would otherwise be difficult to detect, activating forms of situated, sensitive, and relational knowledge (Sobel, 2004; Guerra, 2024).

The observational tools used in outdoor education and, more specifically, in experiences related to biodiversity can be divided into several types, each with a specific pedagogical value, even if they sometimes overlap. The first type concerns more analogical observation tools, which are also typical documentation tools used in environmental fieldwork. Among these, we refer in particular to notebooks (Laws and Lygren, 2020; McClain *et al.*, 2025) – which continue to be widespread and central to naturalistic investigation – necessary for noting discoveries, questions, and reflections, accompanied by graphic tools useful for recording and visualizing observations and ideas in diverse ways and languages, so as to respond to different resources and skills (Guerra, 2020). These diaries or observation notebooks, which have long been used and valued in nature education (Comstock, 1911), encourage not only the collection of empirical data, but also personal narratives and metacognitive reflections, promoting reflective and contextualized learning (Chawla, 2007).

Alongside these, other fundamental tools are optical instruments, such as magnifying glasses, binoculars, and even portable microscopes, which allow access to dimensions of living things that are less and less visible to the naked eye, broadening the horizon of perception and stimulating curiosity and wonder, while facilitating understanding of the ecological interconnections and micro-relationships that constitute a nodal fabric of biodiversity. This group also includes digital technological observation tools, such as cameras and audio recorders, as well as recognition applications on smartphones, which, when used consciously, amplify the possibilities of observing and then documenting and sharing observations, promoting a collaborative and multidimensional approach to environmental knowledge, also in line with the logic of participatory science (Donnelly *et al.*, 2014; Echeverria *et al.*, 2021). Moreover, observations are further developed when they become part of a collective sharing and reflection process, in which observations are discussed, interpreted, and integrated into an interrelational and systemic vision, in a common research effort that simultaneously supports a democratic culture (Warden, 2010).

In short, the adoption of observational tools in biodiversity education allows for the development of transversal skills that start with systematic and critical observation and develop into surveys and documentation, promoting the recognition of biodiversity as a complex system of relationships. These skills represent a fundamental asset for addressing contemporary environmental challenges, recognizing that a deep and sensitive understanding of the natural context is a prerequisite for conservation and sustainability practices (Chawla, 2007; Capra and Luisi, 2016).

Observation tools, considered in their epistemological, pedagogical, and practical dimensions, are therefore an essential element in outdoor education for biodiversity. They are not mere devices, but mediators of a form of embodied, situated, and relational knowledge capable of promoting a deep and lasting connection between individuals and the natural environment. Through the conscious and thoughtful use of these tools, biodiversity education is increasingly taking shape as an educational process aimed not only and not so much at transmitting information, but to train ecologically aware and responsible citizens, capable of inhabiting the world with respect and care, thanks in part to an attitude of openness and curiosity towards all living things that comes from observation, both as a descriptive action and as part of a process of critical construction of ecological knowledge.

Outlook

Consistently, reflections on the perspectives we adopt when encountering the environment and what constitutes it play a central role in this approach. In this vein, exercising multiple and different points of view in order to observe and relate to the environment allows us to highlight the complexity of an authentic ecological and biodiverse education, which requires us to consider perspectives that are often very distant from one another and, in general, difficult to fully comprehend.

One way to experience other perspectives, with respect to ourselves and the environment, is first and foremost to change position, trying to perform the same actions, for example, on the spot or in motion, standing or lying down, up close, or from afar. These simple shifts bring our body and our gaze into conditions that completely change the field we are traversing, also generating significant disorientation. Changing perspective is certainly an anti-economic exercise, because it requires significant resources to reposition ourselves, review our certainties, and deepen our vision from another point of view (Tishman, 2017). However, this use of energy has significant repercussions because it promotes an evolution of our knowledge, which is required to integrate new and often dissonant information.

Alongside this method, another interesting one to experiment with is that which invites us to take on the point of view of another living being: this experience is impossible in itself, since our gaze, even when highly trained, remains subjective, as well as anthropologically determined. However, the problems that this experience generates allow us to open up important reflections, inviting us to gather more information, but also to contain over-interpretations, getting used to hypothesizing in light of what we have experienced, in the awareness that the point of view of another living being, whoever they may be, can only be approached with respect and caution and never fully understood.

Both of these approaches, therefore, allow us to become aware of the partiality and subjectivity of our vision, inviting us to exercise interpretative caution, which is essential for reasoning from a perspective that is as non-anthropocentric as possible, capable of combining – but also distinguishing – imagination and rigor.

Questions (and answers)

The questions, which we present as the last of the proposed categories, constitute one of the central aspects of the approach outlined. Here we refer

to the questions made available by the environment, in the form of invitations and stimuli for curiosity; those proposed by those accompanying an exploratory experience, conveying suggestions that have emerged from previous observations and thus giving shape to interests that are more or less shared by the group; and those of those who experience it directly, which should always be the first and most listened to (Guerra, 2019).

Each of these, if formulated in an open and authentically investigative manner, allows us to exercise the attitude of respectful research, which is probably one of the most interesting skills to develop in evolutionary as well as ecological terms, inviting us to cultivate attention to living things.

At the same time, investigating from an educational perspective for biodiversity calls for the need to construct scientifically based hypotheses that take into account the data already in our possession without, however, reducing the encounter with the environment to that data. In this sense, it becomes crucial not to rush the introduction of codified answers, providing only the information strictly necessary for the research to proceed and thus allowing it to evolve and deepen in a personal and original way. Valuing naive theories, past personal experiences, and recollections originating from memories, while respecting individual perspectives, means allowing different intelligences to engage in dialogue with the environment and with living beings, developing heterogeneous and articulated hypotheses and interpretations, without anticipating the conclusion of ongoing investigations with already known answers, but at least temporarily inhabiting the uncertainty of the outcomes.

This also means recognizing and valuing the relationship between science and imagination (Guerra, 2020), which is not only fertile but even necessary for cultivating an ecological and biodiverse education that knows how to reverberate in the encounter with the other, whatever its form: moving away from a dichotomous logic, which often favors investigations aimed at mere data collection, allows for the cultivation of an extended sensitivity, as well as an awareness of the complexity of our existence in and on the planet.

Conclusion

The categories outlined here constitute the epistemological and methodological structures of an approach that aims to promote an encounter with the environment and its biodiversity, capable of stimulating personal and local interests and interactions while maintaining a global vision. For these reasons, each category introduced is explored from a place-based perspective and, at the same time, a *world-based* perspective, tracing in both

the premises for definitively abandoning transmissive and standardized methods and instead being able to deeply question the reality of which we are a part, through sensitive engagement with authentic issues, so as to make environmental issues fully-fledged subjects of an education that is itself ecological in that it is organic and interrelated.

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From question to question. Cultivating a co-research approach to biodiversity

by *Greta Persico*

An answer is the stretch of road you've left behind,
Only a question can point beyond.
(Gaarder, 1996)

Giving value to experience

Approaching an environment through exploration is first and foremost an invitation.

The act of exploration as an educational experience (Guerra, 2019) is understood here as open, free from judgment and predetermined expectations about what happens or could happen in a given environment. The experience is shaped by the possibilities that arise in the relationship between people – adults and children – contexts and natural elements present in them, and what finds space and recognition in the formation of these relationships. What we pay attention to, what we decide to value, or even what we legitimize, consciously or unconsciously, can radically change the type of educational experience and the learning that takes place within it.

The attitude of non-judgment and constant listening therefore appears to be a backdrop that accompanies the experience in its entirety and invites adult role models to adopt a pedagogically connoted and at the same time non-obvious stance in the learning processes.

The potential of the physical environment in which biodiversity education proposals take shape can be fully realized when the accompanying methodological considerations favor the creation of an educational environment that is configured within an ecological framework (Mortari, 2020). In this framework, the dimensions of interdependence and relationality, which are central to biodiversity studies, are both content and container, pervading the premises within which the relationship between those who accompany the experience and those who are accompanied is established. This gives rise to two useful points for reflection in this contribution: overcoming, or at least striving to overcome, the adult-centrism of educational figures; and, as already noted at the end of the previous chapter, recognizing and legitimizing the heterogeneity of research paths and

the knowledge that springs from them. Placing the personal and collective experience of children and youth¹, at the center is, for those who accompany them, a constant exhortation to listen and observe; a meticulous training in moving away from the tendency to intervene, guide processes, ask questions (in some cases very valuable and the subject of this contribution, to which we will return below) and even more so to provide answers. In other words, consciously interpreting power asymmetries present in the educational scene, working intentionally to change them in the direction of greater horizontality, involves the effort of confronting new relational structures.

It is precisely from these that the possibility of engaging in co-research experiences takes shape, in which each person is an active and integral part of a process that is both individual and collective. The elements of interest and the questions that are formulated thus manifest themselves as *genuine problems* (Dewey, 1992), i.e., issues that are meaningful to those who formulate them because they arise from an involvement with the places and are not induced by hetero-directed constraints such as rigidly interpreted school curricula or priorities established in the choice of content by educational or teaching staff. We can also define these problems as points of interest that give rise to thought processes and potential avenues of investigation.

In the exploratory experience, this process, which starts from a free and unstructured relationship with a place and leads to the desire to understand and learn more about a specific element or phenomenon, based on the interest generated by the encounter with it, is perhaps the defining element of an approach that aims to restore the centrality of questions, moving away from the urgency of quickly arriving at unique and definitive answers.

Starting from these premises, we will explore the value of questions and their potential as privileged tools for exercising a co-research approach in educational experiences aimed at discovering and enhancing biodiversity.

The reflections proposed here derive from research carried out by the BEAT² - *Biodiversity Education and Awareness Team* and are also informed by the extensive scientific work conducted on the themes of the ecology of education, ecological education, outdoor education, and *place-based*

¹ In this chapter, we have opted to use gender-neutral language. Fully aware of the extensive scientific debate on this issue and with the aim of making the text easier to read, we have decided to adopt three approaches: alternating between masculine and feminine terms, favoring periphrases (e.g., “the class group”), and, in some cases, introducing the schwa. These measures were taken with the intention of moderating the effect of invisibilisation of certain subjectivities resulting from the overuse of the masculine form.

² For further information on the research group, please refer to the introduction to this volume and the introductory section of the previous chapter.

education in Guerra's publications (among others, 2015, 2019, 2020, 2024), which form the background to this contribution.

Questions of an explorer

The formulation of questions and possible hypotheses occurs first and foremost in the here and now of the relationship between those who have accepted the invitation to explore and their surroundings. Sensory encounters with a given environment or element can in fact spark interest and trigger a desire to learn, anchored to an intrinsic contingent motivation (Guerra, 2020). Questions inhabit this space of possibility, and if they find fertile ground, they can initiate real paths of research; however, in this case, we are faced with a process that is far from obvious or inevitable. If there is not enough time and a favorable relational environment to comfortably occupy this space, which is necessary for questions to emerge, they may remain unexpressed, unspoken, and disappear as easily as they appeared. The interstices of experience in which curiosity is sparked can be different, which is why, in the research conducted by the BEAT group mentioned above, the methodological focus and the tools developed have, among other things, the aim of increasing the ways in which the relationship between people and a given place or element takes shape, acting as true multipliers of possible experiences.

The question «inhabits the place of thought between experience and reflection, constructing itself as an act of reflective thought that translates, that is, draws out children's own experiences to bring them to life» (Galvagno, 2010, p. 150). Within this framework, proposed by the author in reference to philosophical questioning with children, and equally useful for our purposes, we highlight the connection between experience and reflective thinking, within which the act of questioning can push the experience itself even further, in a hermeneutic circle. Multiplying the ways, channels, and languages through which we weave our relationship with the environment, thus accumulating knowledge about it, means multiplying the potential spaces of possibility within which new questions can arise.

Showing the image of an element on the page of a book can stimulate certain questions, while going out into the garden and experiencing that same element – on a sensory, motor, narrative, etc. level – first increases the questions about it and then, from question to question, can potentially open up reflection on the relationships with what surrounds it. In writing about the questions that arise from the relationship with a given object, from doing, and from experiencing it, Zuccoli emphasizes how these are peculiar because

«they, in fact, impose themselves, they do not have to be suggested theoretically, they need to go deeper, to find ways to solve problems, to formulate hypotheses for questions that may seem unsolvable at first» (2009, p.162).

In the case of outdoor exploration, the object as a potential driver of research, as the author defines it, can be a natural element. Questions arise from that encounter and follow one another precisely because of the need to go deeper, as mentioned above, as an intrinsic motivation to understand more and more.

However, this is not just a quantitative issue (many experiences that potentially raise many questions) but also a qualitative one. Plural perspectives (including disciplinary ones) will in fact stimulate heterogeneous lines of research, activating intelligence, skills, and composite views that are distinct from each other and potentially interconnected.

In fact, a range of possible questions opens up, spanning multiple areas of knowledge: questions aimed at satisfying a scientific-naturalistic interest, for example, to understand the specific characteristics of a collected plant element or its similarities and differences with others. Careful, multisensory observation or comparative study are actions that invite us to familiarize ourselves with the importance of the category of species and intraspecies variability in biodiversity. There are also questions that seek to explain phenomena observed in nature, such as the metamorphosis of an animal in the decomposition of a carcass and the reasons why this happens. In investigating cause and effect processes, for example, we retrace the threads that trace the interdependent relationships of living beings, and in doing so we can focus on organic aspects, such as predation, as well as open up metaphysical questions about dying. Furthermore, there are questions that investigate one's own experience and that of others within a philosophical horizon of searching for meaning, for example, by questioning one's role within an environmental context or the cyclical nature of living beings. Moving on, we then encounter – perhaps more frequently – questions that, in their formulation, simultaneously solicit multiple areas of knowledge, straddling, for example, poetic and scientific thought.

The latter, in particular, are questions that may seem unexpected, if not bizarre, to those who, in accompanying an exploratory experience, struggle to adopt the open, legitimizing, and listening posture highlighted at the beginning of this paper. Yet it is precisely in the folds of these questions and the processes of «thought and research that sometimes arise from them, it is possible to develop a perspective capable of grasping elements that would otherwise be elusive» (Guerra, 2020, p. 30).

In educational proposals aimed at understanding biodiversity, precisely because of the complexity that this concept encompasses, it is interesting to consider every point of access as potentially fruitful, i.e., every doubt or curiosity that opens up further exploration.

In fact, we are placed within a horizon in which the explorer is considered part of a co-research process where adult knowledge is no longer more important, or has no greater value, than that of children or young people. This approach invites us to reconsider, at least in part, the relational asymmetries between the subjectivities that share an exploratory experience and, at the same time, invites us not to establish a hierarchy between knowledge or languages. It is therefore desirable that every question not only has full citizenship (Guerra, 2019) and with it the possibility of being made explicit, verbalized, and documented with the chosen tools, but that it can also represent a stimulus to initiate individual research paths or moments of collective discussion and sharing, since it reflects the interest of the individual or group that formulated it. Quoting Guerra, we can say that «the question, therefore, can be seen as the first research tool, as the spark that illuminates the start of the process» (2019, p. 98).

By highlighting a detail of the experience, the question brings it to the fore, giving visibility to what until a moment before had remained unseen. This is why the use (or non-use) of questions by educators can significantly guide an exploratory process and the relationship that is established with that environment.

Between silence and questions. Creating spaces for reflection

After addressing the importance of the questions that children, boys, and girls, bring to their explorations, and in keeping with a proposal that sees adults researching alongside those accompanying them, we now intend to focus specifically on the questions of educators.

In affirming everyone's legitimacy in asking questions, it is clear that this also includes the adults who facilitate the experience: each person can «bring their own perspective, their own interpretation of things, their own questioning into the shared territory of the educational community» (Guerra, 2020, p. 94).

In the context of biodiversity education proposals (Persico, 2024) based on experiential and place-based approaches (Guerra, 2024), attention to the relationship with places is also central to the personal experience of those accompanying. Interest in nature and its elements, curiosity about what lies

beyond the educational service, and the desire to interact with it in order to learn and observe it are, in fact, distinctive traits easily found in those who propose an educational approach aimed at enhancing the practice of the outdoors (Schiavone, 2024).

This is why we believe it is interesting to emphasize how the curiosities and interests of those accompanying them, sparked by an encounter with a place or a specific element, can also find space in the pages of notebooks or documentation tools chosen for this purpose.

Being engaged in research with one's group means sharing a questioning and curious attitude, first and foremost, with respect to one's own experience of relating to the world. Beyond the joy of fostering discovery, having a gaze capable of grasping what is not immediately visible is a skill that will make it easier to recognize potential and interesting elements in the research and observations shared by others.

There are also questions that support reflective thinking useful for those who guide the experience. Keeping track of one's questions, born from observation of the environment, simultaneously brings with it a careful analysis of the interactions that occur between that environment and those who pass through it.

Proper documentation, especially in outdoor contexts (Guerra and Luini, 2026), is invaluable for capturing elements of interest, ways of relating to them and to the place, and relational dynamics useful for guiding the questions that those who guide ask children. For questions in education to continue to stimulate thought, Guerra writes, «these must nevertheless be well-founded for those to whom they are posed, so as to foster the meaningfulness of the experience that may follow» (2019, p. 95)

We have repeatedly emphasized the importance of valuing the questions that arise from the direct experience of children, taking advantage of them as opportunities to launch research avenues, formulate hypotheses, and explore specific topics.

An equally significant role can be played by questions posed by those accompanying the group, facilitating discussion of open issues and offering stimuli that capture and revitalize observed interests and hypotheses of individuals or the group. The return to a collective dimension of speaking out, aimed at sharing one's own questions and hypotheses within the group, allows "individual questioning" to become a shared heritage.

Precisely in this sharing, as Zuccoli (2009) reminds us, referring to the two variables that Dewey identifies as interesting in relation to questions, the instinct to investigate is accompanied by that of conversation.

A middle ground, a place where questions can dwell, where one can remain in the constructive doubt of knowledge, where one can remain suspended on the edge of one's own opinions and transcend one's own conditions (Galvagno, 2010, p. 167).

The middle ground of collective discussion, in the discovery and understanding of biodiversity, can take shape at a slow pace that fosters the continuity (Persico, 2024) of increasingly in-depth research: through discussion, it is possible to identify avenues of shared interest, validate hypotheses, formulate new ones, and then explore other sources. This allows the information gathered through direct exploratory activity to be integrated not only with the multiple perspectives of those who shared it, but also with other knowledge, materials, witnesses, and sources.

In facilitating collective thought processes, it is important for those who guide them to be aware that knowing how to inhabit questions also means being able to remain in silence, a necessary dimension for thought to progress. Indeed, some research suggests that there is a relationship between teachers' ability to wait – in silence, to be precise – and the relational and cultural climate of the classroom context; furthermore, that prolonged waiting times lead to more nuanced, creative, and unexpected responses (Garvey, 1984).

Giving value to questions

To enhance the lived experience and facilitate dialogue through a questioning approach to oneself and the world, several precautions can be adopted. We've already mentioned the importance of listening first and foremost to those you're accompanying, offering a positive, encouraging presence, including through verbal and nonverbal cues. Time, preferably slow, is another variable that can foster a fertile environment for expressing one's questions and the avenues of inquiry they generate.

Furthermore, it's helpful to remind those accompanying you to keep track of their questions both during the exploration and at its conclusion. Writing them down, even when they may appear at an earlier stage, allows you to capture the flow of thoughts that punctuated the experience as it unfolded.

It's possible that not all the questions or hypotheses written in your notebook will be equally interesting or explored, but this material will remain as a signpost for the mental journey emerging from the relationship with the places. In other words, the questions collected throughout the experience, whether sketched out or more elaborate, represent a map that can guide both

the person who created it and the reference figures in understanding what happened, even after some time.

If it's possible to map places through exploration, it's through the ongoing documentation of questions that the thought processes and elaboration of the experience are mapped.

The type of questions and how they are formulated can change over time, as interests, perspectives, and the accumulation of knowledge evolve through frequent visits to one or more places.

Another tip might be to invite the person in front of you to rephrase the question to see if you've truly understood what they meant. In doing so, you can use other words to highlight nuances of meaning that you believe can capture the heart of the question itself. Making sure you've understood is a skill that, in addition to allowing the person in front of you to clarify any misunderstandings, helps create a climate of recognition and listening. In some cases, it may be helpful to ask for further clarification of the meaning attributed to one or more words, both to encourage accurate use of terminology and to make individual questions a resource for shared thought.

Some questions can be explored in depth by recalling previous biographical experiences; This focus fosters a connection, even an emotional one, to familiar contexts and can support a comparative approach between elements, such as recognizing a tree because its fruit has already been eaten elsewhere.

Valuing the biographical experiences of boys and girls, through reflections that are consistent with the topic addressed but allow them space to share, can strengthen their ability to create connections when interpreting environmental contexts, including from a naturalistic perspective, as well as the connection of natural events such as the seasonal migration of a flock. At the same time, this fosters the creation of a stimulating educational environment that values individuals.

It is now well known that biodiversity is close to us and present, albeit in different forms, in all contexts of life. Learning to see and recognize it therefore means training ourselves to adopt an interested and questioning stance in our relationship with the world. Indeed, when we begin to see biodiversity all around us (Campbell-Arvai, 2019; Deparis *et al.*, 2023), it becomes inevitable to notice and intercept it wherever we go, even in a city flowerbed or among the vagabonds (Merisi, 2017) of a sidewalk.

Conclusions for possible answers and new questions

In the context of research investigating tools and methods of education for biodiversity (Persico, 2024), this proposal appears to be quite novel and innovative. In fact, in the literature, even in research that can be compared to it due to methodological considerations (Afonso *et al.*, 2021; Mota *et al.*, 2021; Matos *et al.*, 2022), let's think for example of the experiential and place-based nature that characterizes them.

The use of questions is diverse. Indeed, they are predominantly externally directed, proposed by those who planned the exploration, and in limited numbers.

In this chapter, we have explored the role of questions as signals of interest sparked by an encounter with the environment, and an approach that, through them, proposes research as a posture in the relationship with places and the biodiversity present there. In renegotiating certain balances, this proposal is not naive with respect to the awareness that knowledge-building processes that are highly experiential and, in some respects, maieutic must engage with content, definitions, and knowledge codified and shared within the relevant scientific communities. In all this investigation of questions, it is therefore legitimate to ask what place answers occupy. We have already outlined some useful considerations for facilitating the process of knowledge construction and for systematizing the answers to the many questions arising from experience and discussion within the group. At the same time, it's perhaps useful to point out that, within the framework outlined thus far, the most interesting aspect is how these answers are formulated – that is, thanks to which sources and through which processes of co-construction of knowledge, and ultimately, within what timeframe. Adopting a questioning and research-based approach, shared with the developing individuals with whom one is working, therefore means engaging in a process of building shared knowledge.

It requires a certain willingness to choose a path, perhaps longer and certainly more complex, in which the facilitator's role is not to offer readily available and predetermined answers, but rather to cultivate relationships between individual subjects and a given environment, waiting for topics and themes to be explored to emerge within them. Then, knowing how to grasp these interests and accompany the resulting hypotheses in a genuinely engaged dialogue.

The answers will therefore be multiple: in some cases it will be necessary for them to remain as such, while in others the work of comparison and in-depth analysis will lead to limiting their relevance, discarding ephemeral conclusions (Sclavi, 2003) and over time refining not only naturalistic

intelligence but also the categories, nomenclatures, and definitions appropriate for describing one's encounters.

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Documenting biodiversity with children: characteristics and methodological potential of the process

by *Letizia Luini*

Some considerations on documenting outdoors

Every context, starting with the closest and most accessible (Guerra, 2020), was considered an opportunity to explore the biodiversity of the places visited, both for the children and the adults accompanying them, who at the same time experienced firsthand the processes of outdoor research. From this perspective, a review of the literature on biodiversity education (Persico, 2024) highlights a number of points to consider: first, any context, however seemingly devoid of elements of interest, can represent an environment rich in animal and plant species, but above all a resource for the protection of biodiversity. Specifically, the study conducted by Muvengwi *et al.* (2019) shows that even environments such as schoolyards can be centers for biodiversity conservation for both native and exotic plant species. Secondly, attention is drawn to the importance of the experiential dimension (Guerra, 2019), which can reinforce the sense of connection between people and the environment (Navarro-Perez and Tidball, 2012) and promote more personal learning experiences that take shape from each individual's interests. Finally, interdisciplinary (Da Costa-Lima, 2009) and participatory (Katili *et al.*, 2021; Feio *et al.*, 2022) approaches are described as particularly promising, in the awareness that environmental issues cannot be separated from cultural and social ones, and that they must actively involve citizens in their exploration, understanding, and enhancement.

From this perspective, keeping track of what happens outside is a dynamic action that can make visible the learning processes, investigations, discoveries, and questions (Dahlberg *et al.*, 1999) that arise from direct encounters with biodiversity. As will be discussed in more detail shortly, documentation is a pedagogical practice that can capture the above-mentioned dimensions, which are essential for cultivating an active,

immersive, and place-based approach (Persico *et al.*, 2024) of biodiversity education, highlighting the interests, needs, questions, and hypotheses of those who explore, who in this sense have the opportunity to play an active role in environmental issues, starting from the most immediate local context (Persico, 2024). In fact, the possibility of documenting encounters, discoveries, research paths, and initial hypotheses developed from direct encounters with the world (Guerra, 2020), especially those immediately outside the school walls, allows us to recognize the value of what happens and can happen there (Guerra, 2020; Gottardo and Restiglian, 2024). This practice, therefore, places the emphasis not only on content but above all on processes (Dahlberg *et al.*, 1999), supporting critical and shared reflection involving both adults and children, with the aim of co-constructing meanings and developing new awareness based on what has been made visible, the starting point for knowledge acquisition processes.

Documenting what happens outside is therefore never a simple act of recording, but an intentional, recursive, and reflective process that allows us to highlight the procedural essence of learning through an approach based on listening, deep observation, and the shared co-construction of knowledge (Fleet, Patterson, and Robertson, 2012). In this sense, we move away from the desire to pursue learning standards in favor of more personal investigative processes (Gottardo and Restiglian, 2024), which are achieved through the exercise of a pedagogical strategy that allows us to observe, narrate, and analyze research within an interpretative space of possibility, but also to attribute new meanings to discoveries in order to open up unexplored avenues of research based on questions that arise along the way.

Documenting in outdoor environments, which are by their nature unpredictable, transient, and often more complex to observe and record than more structured ones (Guerra, 2020), requires deep professional awareness and focused attention to the selection of materials and questions that guide their collection: on a methodological level, this means facing challenges that call for a change of attitude in favor of flexibility, reflective listening (Antonietti, 2017), and a slowing down of immediate interventions in order to fully grasp the deeper meanings of the experiences lived (Guerra, 2020). Therefore, documenting in such contexts, while fully recognizing their complexity, can offer significant methodological advantages that affect both the adults who accompany outdoor experiences and the children and youth who can take part in the production of documentary material.

Firstly, direct encounters with biodiverse environments, captured through the use of a variety of documentation tools, activate observation processes specific to the natural world (Leslie and Roth, 2000; Johnson, 2014): graphic representations, photographic images, or more or less detailed annotations

mediate the development of observation skills, consolidate connection with nature, and promote the progressive construction of ecological awareness (Cormell and Ivey, 2012). The documentation process, in fact, enhances the connection with the places visited, promoting learning based on the local context and interactions with natural ecosystems and nearby communities (McClain *et al.*, 2024), strengthening in both adults and children a deeper environmental awareness, mediated by the construction of meaningful bonds with nature and the territory, which can counteract the risk of alienation from natural contexts (*Ibid.*).

By virtue of what is achieved outside, and so that both adults and children can be actively involved in this process, the practice invites the implementation of a plurality of languages that are more likely to capture and convey the complexity of what is happening, proving to be inclusive tools for giving voice to lived experiences, which are also made visible to others. From this point of view, as mentioned, it is possible to draw on images, texts, drawings, videos, maps, or collections (Guerra and Luini, 2024), which can be used individually or in multimodal combinations (*Ibid.*) to observe, record, and communicate experiences in a richer and more complete way. This plurality of codes stimulates different types of thinking, encourages creativity, and allows everyone to represent their own point of view, strengthening the link between themselves, their lived experience, and the diverse nature, recounted in all its many facets: the methods used, which are not alternative but complementary, thus contributing to the construction of a multifaceted image of the outdoor learning experience (Tsevreni, 2021). Documenting with a variety of languages, chosen by each individual based on their skills, inclinations, and what they are actually observing, also allows for the integration of educational planning in an interdisciplinary way, supporting the learning of literature, mathematics, art, and science through concrete, situated, and self-directed experiences (Miur Laws and Lygren, 2020).

Documenting in outdoor contexts responds not only to educational needs, but also to cultural and political ones: it allows education in nature and for biodiversity to be given visibility, legitimizing it as an integral part of a broader educational project, opposing the perception that often relegates such practices to marginal, recreational, or optional activities (Garden, 2023). The process, therefore, restores the full educational value of concrete experiences, which are significant not only for the acquisition of disciplinary content, but above all for the exercise of active citizenship, made possible by an intrinsically participatory practice. From this point of view, allowing even the youngest children to take part in the production of documentation makes it possible to enhance their relationship with the places they visit, making

visible deep-rooted and personal learning, often neglected in more traditional educational practices (*Ibid.*): in fact, documenting questions and initial hypotheses firsthand promotes subjective reflection and critical thinking (Bennion and Olsen, 2002; Dymont and O'Connell, 2003). This approach, therefore, encourages the protagonism of children and youth, who in this sense take on the role of active co-constructors of knowledge, in line with the most recent concepts of childhood and with an idea of education for biodiversity that increasingly promotes the direct involvement of all citizens in concrete actions in nature, aimed at increasing ecological awareness (Ikin *et al.*, 2015). Documenting with younger people therefore means recognizing them as competent individuals with agency (Oliveira-Formosinho and de Sousa, 2019), contributing significantly to the promotion of democratic and participatory education through practices shared between children, teachers, and adult family members.

The notebook tool

Among the various tools that can accommodate multiple languages and perspectives in support of the documentation process, the notebook plays a significant role: it has its roots in a long tradition of explorers, scientists, and naturalists who, since ancient times, have recorded their discoveries in personal journals (Leslie and Roth, 2000). Documenting in a notebook, for both young people and adults, is a promising pedagogical resource: in fact, the notebook, a versatile, pocket-sized object that is accessible even to the youngest children, allows them to observe, record, reflect, and rework their experiences, experimenting with a personal space for the construction of knowledge and interaction with the natural world. Multiple languages coexist within it, each of which allows one's own interpretations to emerge in the world, strengthening the sense of connection with the environments explored: notebooks are fundamental tools not only for scientific research, but also and above all for the development of ecological thinking, allowing everyone to document details, patterns, and seasonal changes, becoming a veritable archive of memory and a space for the growth of thought (Warkentin, 2011). According to King and LaRocco (2006), notebooks are a means through which individuals clarify their thoughts and give shape to their reflections, establishing connections and attributing meaning to what they observe and experience (Tsevreini, 2021), transforming the experience itself into learning.

The use of notebooks as a teaching tool has been documented in various formal contexts, from primary school to university (McMillan and Wilhelm, 2007; Cornell and Ivey, 2012; Mueller and Pentón Herrera, 2023), and the results of various studies highlight that it allows for careful observation, trains concentration, improves drawing and writing skills, exercises reflexivity, and develops a sense of place (Leslie and Roth, 2003). Despite the scarcity of systematic studies involving early childhood, the literature hypothesizes its effectiveness, based on research conducted with young people and adults: keeping a notebook to document outdoor experiences can stimulate ecological and linguistic literacy, acting as a bridge between sensory experiences and written expression, increasing empathy towards nature (Sobel, 2008), a sense of wonder (Carson, 1965), and creative expression (Johnson, 2014; Miur Laws and Lygren, 2020). The notebook also encompasses different disciplines and learning styles, proving to be a flexible and inclusive tool to accompany outdoor experiences. In fact, it promotes individualized learning, encourages the subjective construction of knowledge, and can also be adopted in urban environments with limited access to nature (Miur Laws and Lygren, 2020), a feature that, as mentioned, would seem to be significant in biodiversity education experiences (Persico, 2024). In the urban context in particular, the tool helps to reactivate sensory attention, stimulates ecological, historical, and social questions, and sharpens ecological awareness (Warkentin, 2011).

The notebook is not only a tool for observation but also for interdisciplinary interpretation of the experience, as it allows science to be linked to art, writing to reflection, and knowledge to action (Miur Laws and Lygren, 2020), helping to develop curiosity and stimulate complex cognitive processes. Furthermore, the possibility of sharing the contents of one's notebook makes this tool a vehicle for collaborative learning and collective exploration of the natural environment (Mueller and Herrera, 2023), allowing students of different ages to document local environmental issues, reflect on landscape transformations, and integrate the evidence collected into active citizenship programs or participatory educational initiatives, for example through letters to newspapers, messages to stakeholders, or specific school projects (Warkentin, 2011; Muir Laws and Lygren, 2020). In this sense, Heinrich (2011) observes that meticulously noting one's observations and then sharing them with others allows one to move from a passive role as a witness to an active role as an explorer questioning reality: the notebook, therefore, acts as a real tool for documentation, investigation, critical reflection, and reporting, promoting a deeper understanding of the relationship between the observer and the observed context (Smith, 2011; Meier, 2020). In conclusion, it is a space in which to cultivate thoughts, ideas,

and observations, and where nature can leave a permanent mark, through a function that is not only descriptive, but also reflective and transformative (Anderson, 2019).

Children as protagonists in the documentation process

Providing notebooks to children during outdoor experiences can therefore contribute to enhancing their participation, as each child can highlight their personal interests and hypotheses regarding local biodiversity, explore subjective research paths, and share their reflections both inside and outside of school, engaging with privileged interlocutors (Dardanou and Karlsen, 2023). Several studies (Kathili *et al.*, 2021; Tumbaga *et al.*, 2021) highlight that even the youngest children should have the opportunity to actively contribute to the enhancement of biodiversity by helping to produce documentation and participating in decision-making processes (Feio *et al.*, 2022) that can have an impact on their own and others' experiences as citizens of the world (Luini, 2024). In this perspective, the literature highlights the role of outdoor documentation as a participatory tool, capable of connecting theory, policy, and educational practice, actively involving children, teachers, and families (Muela *et al.*, 2019) in a shared construction of knowledge (Fleet, Patterson, and Robertson, 2017; Oliveira-Formosinho and de Sousa, 2019).

Documenting in a notebook is therefore a practice capable of enhancing the protagonism of children, understood as co-researchers and producers of meaning, who can collect hypotheses and scientific evidence by tracing memories and at the same time reworking their experiences, including through the sharing of materials with peers and adult references (Gottardo and Restiglian, 2024). Merewether (2018) describes documentation as a space for co-constructing meaning, a process that supports children's agency and awareness in outdoor learning (Tan and Yang, 2022). Using a notebook outdoors also improves the literacy skills of young children who enjoy the opportunity to choose storytelling tools and methods, a process that also seems capable of harmonizing the voices of children and teachers, promoting the development of skills such as reflectiveness, flexibility, and collaboration (*Ibid.*). However, as Clark and Moss (2011) and Spyrou (2011) point out, even practices and tools designed to enhance the voices of young children and rebalance power relations with adults may, paradoxically, risk reiterating adult-centric logic: from this perspective, recognition of this ambivalence calls for the adoption of dialogic and ethical approaches (Kumpulainen and Ouakrim-Soivio, 2019), which are discussed in more detail below.

Sharing documentation (ethically)

As mentioned, a typical step in the documentation process, so that it does not become an end in itself, but continues to generate new hypotheses, consists in sharing it: the dissemination of documentation with different interlocutors and in different contexts highlights the importance of recognizing the right of children to decide whether and how to disclose their naturalistic reflections. While representing a valuable opportunity for participation and the shared construction of ecological meanings with the community, the public dissemination of documentation and the participatory processes that derive from it, particularly relevant in the field of biodiversity education (Luini, 2024), raise important ethical issues related to the direct involvement of children. In this sense, the relationship between the individual and the community in which they live can be oriented to enhance their protagonism, and educational contexts can become places for the construction of culture and active democracy (Giudici, Rinaldi, and Krechevsky, 2009): designing together what, how, and with whom to share the materials progressively produced implies recognizing children as subjects capable of self-determination, entitled to express consent or dissent regarding the use of their notebooks.

In line with a participatory methodological approach, attention to informed consent (Einarsdóttir, 2007) is configured as a practice fundamental to honoring the right to expression and participation (UN, 1989); consent, however, should not be understood as a formal and isolated act, but rather as a dynamic process that allows everyone to freely choose whether or not to take part in a proposal, such as the possibility of disseminating their notebooks. From this perspective, it requires adults to listen carefully and be genuinely willing to renegotiate the involvement of those involved (Eckhoff, 2015), by providing spaces for dialogue and collective reflection on the fate of the documentation, so that it can only be disseminated by mutual consent (Alderson, 2012; Dockett, Einarsdóttir, and Perry, 2012). Therefore, the documentation of outdoor experiences, especially when it aims to foster dialogue with the places where it was produced and promotes the active participation of young people in communication and awareness-raising on environmental issues, such as those related to biodiversity (Kathili *et al.*, 2021), cannot ignore a profound ethic of relationship: recognizing young people as competent and trustworthy subjects means listening to and respecting their expressions, whether written, graphic, or narrative, guaranteeing them the right to consent. Asking for consent therefore implies valuing their autonomy, respecting their privacy, and stimulating critical reflection on the meanings to be conveyed, the

recipients of the communication, and the very possibility of sharing. In this sense, documenting outdoor experiences is not only a pedagogical tool, but also an opportunity for education in citizenship and responsibility: a political action of active participation, in which children exercise their role as co-authors in the dissemination of their experiences, helping to raise awareness among adults of the naturalistic richness present in their notebooks.

Concluding thoughts

In light of these considerations, therefore, documenting outdoor experiences cannot be reduced to a simple archive of memories, but is a true reflective device (Fleet, Patterson, and Robertson, 2012), participatory and transformative (Merewether, 2018): a tool for research, communication, and collective action in relation to environmental issues, capable of making complex processes visible and enhancing the role of young people (Feio *et al.*, 2022).

In terms of education, keeping a notebook creates a bridge between experience and knowledge, which can transform a concrete memory into an opportunity to explore scientific concepts in greater depth (Miur Laws and Lygren, 2020): a detail noticed or an environmental change can become the starting point for broader investigations, linking observational practice to the acquisition of new knowledge and the understanding of complex environmental phenomena. Choosing what to document and how to do so gives children the opportunity to exercise agency (Oliveira-Formosinho and de Sousa, 2019), becoming active observers of the natural environment and decision-makers in their own explorations, while reviewing, retracing in groups, and re-examining the issues that emerged from their notebooks allows them to reactivate their memory of the experience, stimulating profound questions, shared reflections, and deep learning (Guerra, 2020).

As we have seen, a significant aspect of the process, especially in relation to participation, is the sharing of documentation: making experiences visible in public spaces, from the school garden to the neighborhood square, allows a wide range of recipients to be reached, enabling children to take an active role both in constructing meaning from their own experiences and in disseminating scientific knowledge. Designing the exhibition experience together, with informed consent, means involving them in a deliberate process that invites them to reflect on what, how, and with whom to share, to question the messages to be conveyed and the audiences to be reached, weaving dialogues with stakeholders and citizens: in this sense, everyone can

take an active role in building knowledge about biodiversity, starting with the recognition of the voices and perspectives of the youngest.

Documentation, through the primary tool of the notebook, thus becomes a shared language and approach, capable of communicating what has been observed, thought, and experienced: consciously participating in its production and sharing promotes recognition of younger people as co-authors of meaning and not simply consumers of knowledge.

In conclusion, outdoor documentation in notebooks is a transformative educational practice, capable of intertwining observation, reflection, participation, and sharing: far from being a simple recording tool, it becomes a space for constructing meaning, enhancing agency, and developing greater ecological awareness. The natural context, with its wealth of stimuli and unpredictability, is a privileged environment for experiential learning and education about biodiversity: from this point of view, documentation amplifies expressive and reflective possibilities, promoting an educational practice that focuses on the subject, their view of the world, and their relationship with others, making visible the often silent but significant processes that take place. Publicly sharing documented experiences not only legitimizes the intrinsic value of biodiversity education, but also opens up collective participation and social recognition of children's knowledge. In this sense, documenting also means taking an ethical and political stance that honors the right to participation, highlighting the deep connections that children know how to weave with a world inhabited by multiple forms of life: thus, documentation becomes not only a memory of experience, but a generative practice, a reflective device, an invitation to consider children's relationships with biodiversity as a living resource for imagining a more equitable future, and a strategy capable of opening up new forms of relationships with the world, starting from the perspectives of the youngest.

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Participatory approaches to preserving biodiversity. The potential of *photovoice* for children

by *Letizia Luini*

Promoting biodiversity conservation with children through participatory approaches

Currently, children, youth, and adults are facing a global crisis that combines multiple environmental problems, particularly related to climate change, biodiversity loss and degradation, and economic and social fragility, posing a threat that risks compromising the achievement of the human rights declared in the *2030 Agenda for Sustainable Development* (UN, 2015).

As discussed at length in other sections of this volume, experts express considerable concern about the current state of our ecosystems and highlight that nature conservation is an urgent issue that must be taken seriously (Katili *et al.*, 2021), a complex global problem that affects everyone and requires careful, timely, and comprehensive responses. Biodiversity conservation is therefore an urgent challenge for all of humanity (Watson *et al.*, 2021), for adults and children, who on the one hand represent one of the most at-risk populations, and on the other are those who have fewer opportunities to contribute significantly to the prevention of environmental degradation, despite the United Nations High Commissioner for Human Rights and the Human Rights Council of the The United Nations (HRC) stating that children are the key to effectively achieving a more sustainable future (Shields *et al.*, 2023).

It is therefore clear that in order to tackle environmental problems such as biodiversity loss, it is necessary to promote direct and ongoing contact experiences, as well as actively involving people who are not necessarily experts in the field in decision-making processes, but who through their daily actions can encourage contextualized and sustainable biodiversity conservation programs. In this sense, children should be able to inhabit, encounter, and experience their surrounding environment as a source of constant knowledge and learning through direct experiences: in fact, the interaction of living beings

with their environment should not be transmitted by memorizing abstract content, but should be achieved through empirical experiences, starting with exploration and in-depth knowledge of the closest environments (Guerra, 2020; Katili *et al.*, 2021), such as gardens, courtyards, city parks, sidewalks, and more, even if they appear to be more anthropized. They are in fact rich in opportunities for discovery (Guerra, 2022). These opportunities support the creation of deep connections with the environment (Mahidin and Maulan, 2012; Lehmann, 2019), increasing empathy and the desire to reconnect with them, an intense and deep-rooted bond capable of triggering that desire for commitment and responsibility in the conservation of different species as subjects worthy of care and protection. In fact, increasing environmental awareness primarily involves developing a deep love for nature, which can enable children to interact with it in a respectful, conscious, and ecological manner (Mortari, 1998; Guerra, 2020), allowing everyone to feel part of a whole, significantly changing their attitudes: experiencing an environment firsthand can therefore allow us to fully understand it through all senses, re-establishing a stronger bond and beginning to understand more clearly the close relationships that exist between us and the world around us, promoting a situated understanding of the direct consequences of our actions. This can even be determined simply by our passing through a place, an action capable of altering micro-dynamics and delicate balances. In fact, as highlighted in the works of Cohen (2016) and Katili *et al.* (2021), understanding ecosystem relationships should be achieved by directly analyzing real natural phenomena, starting with those that can be observed in everyday life.

These considerations therefore allow us to develop an awareness that environmental problems are personal and collective issues that affect each and every one of us: in this sense, the conservation of biodiversity is a matter that involves all human beings, and in order to achieve this, it is crucial to promote experiential and innovative methods capable of encouraging young and old alike to be active and participatory (Schaal, Matt, and Grübmeier, 2012): children should therefore have the opportunity to take action and contribute to the transformation of practices and attitudes from an early age, actively participating in decision-making processes (Feio *et al.*, 2022) that can have an impact on their own and others' experiences as citizens of the world.

As also emerges from the research conducted by Tumbaga *et al.* (2021), the importance of community participation as an essential tool for managing environmental problems should be further emphasized: in fact, as we have seen, a higher and more contextualized level of understanding of environmental dynamics could enable the inhabitants of a place to develop proactive attitudes and thus a greater level of participation. Therefore, emphasizing community-based resource management models, which involve the assumption of responsibility by people belonging to groups

marginalized from decision-making processes, such as children (*Ibid.*), is an essential commitment to protecting biodiversity.

However, as mentioned, children and youth are not usually considered in discussions on environmental issues but rather are the subject of standardized, frontal, and traditional learning experiences that provide decontextualized examples or content mnemonics that do not promote that essential connection with the subject of investigation (Guerra, 2020; Guerra, 2021a, 2021b; Katili *et al.*, 2021) and that pay little attention to all those methodological aspects that can instead guarantee the formation of critical awareness in biodiversity conservation (*Ibid.*).

Educators and teachers therefore have a responsibility to promote reflection, questioning, and research on these issues, going far beyond content-based teaching to explain how human attitudes influence biodiversity (Cohen, 2016), embracing instead observational, dialogical, reflective, and transformative approaches that can support civic participation and the connection with both society and the place being investigated (Mahidin and Maulan, 2012), in order to find creative responses to phenomena occurring in the natural environment (Katili *et al.*, 2021).

It therefore appears necessary to experiment with new pedagogies to enable children to generate their own data and documentation for the study of biodiversity (Cohen, 2016) through the implementation of tools, approaches, and languages that are appropriate to their skills. In particular, combining active and participatory learning methods with ongoing field experiences can improve biodiversity skills (Ramadoss, 2011). These assumptions therefore accompany a reflection that aims to promote participatory, transformative, and multimodal approaches and methods (Montreuil *et al.*, 2021) as tools capable of increasing literacy levels in relation to biodiversity conservation, in line with the *GreenComp* (European Commission, 2022), which calls for training in the use of systemic and critical thinking, necessary to address complex issues such as the one just described, enabling research, information gathering, and the dissemination of evidence on species loss through the direct contribution of everyone (Navarro-Perez and Tidball, 2012).

Children as active agents of change through emancipatory and visual tools

The right of children to take part in decision-making processes that affect their living environments appears to be broadly defined (UN, 1989). However, the *Knox Report* (2018) states that children's human rights must

also be integrated into international discussions on the future of the environment, a consideration that is supported by the *Global Biodiversity Framework* (2022), a document that includes a specific objective aimed at ensuring fair and inclusive representation and participation of the needs of children and youth in decision-making processes related to biodiversity in order to guarantee the full protection of children's rights to the environment, facilitating opportunities for children to participate in a respectful and transparent manner (*Ibid.*).

In this sense, with regard to environmental issues, the successful inclusion of children in movements for environmental justice and equity has been partly precluded by adult perceptions that attribute to young people the status of victims (Daly, 2022) who suffer and endure environmental degradation. In contrast, recognizing children as active subjects (Corsaro, 1997; James, Jenks and Prout, 1998) and experts in their own lives (Clark and Moss, 2011) can instead allow adults to place trust in children and learn from and with them, promoting an intergenerational and transformative dialogue based on a few key assumptions: firstly, children have a different cognition than adults, as their experiences of time and place are different and therefore they can offer innovative thinking to improve decision-making processes on environmental issues; secondly, the promotion of enjoyable and engaging participatory processes can foster the creation of fruitful relationships between children and adults, disrupting more traditional methods that view research as an objective and neutral process, and moving instead towards approaches linked to subjectivity and creativity, based on relationships of trust between participants, which are crucial attitudes if we intend to engage critically with environmental issues (Shields *et al.*, 2023).

Children are eager to share their views on the world and make decisions about issues that matter to them through knowledge co-construction (Leitch *et al.*, 2007) and empowerment tools (Allmark, Stevenson, and Stotzer, 2013) that involve the use of participatory, ethical, sensitive, and multimodal techniques and methods (Barker and Weller, 2003; Sanders and Munford, 2005) and take into account the specific characteristics and needs of participants (Christensen and Prout, 2002; Punch, 2002), allowing them to perceive themselves as active agents of change, and therefore capable of influencing environmental and other issues.

From this point of view, the literature highlights that using participatory and visual techniques with children can promote concrete possibilities for change (Clark and Moss, 2011): these approaches mainly use images as a channel for communication and dialogue, allowing meanings to be explored and knowledge to be disseminated (Rose, 2014) through a language compatible with the skills of younger people (Johnson, Pfister, and Vindrola-

Padros, 2012). Therefore, multimodal and dialogic documentary practices can play a central role in this reflection, facilitating the expression and participation of children and youth around sensitive subjects of investigation in which, as mentioned, it is crucial to value direct, experiential, and collaborative contributions, as they are potentially transformative.

Photovoice: a participatory and transformative approach to biodiversity conservation

A promising participatory-visual approach to addressing some of the above needs, particularly when implemented by children (Luini and Guerra, 2023), is the photovoice methodology (Wang and Burris, 1997; Wang, 1999), a process during which groups of people who are rarely listened to with regard to problematic situations that affect them firsthand, such as children with regard to issues related to biodiversity protection, can identify, represent, and improve their community through a series of experiences (Sutton-Brown, 2014) that can be transformed into opportunities for environmental and political action.

This methodology is often used to document one's life experiences and to collectively discover the roots underlying certain problematic situations (Freire, 1970), incorporating the voices of community members in the collection, analysis, and dissemination of information through processes of change that directly involve both individuals and the community itself, appearing to be a process capable of promoting participation as an essential tool for managing complex problems such as environmental ones (Tumbaga *et al.*, 2021).

The approach involves proposing a series of steps (Butschi and Hedderich, 2012; Latz and Mulvihill, 2017) which, when combined progressively, emphasize active involvement in one or more stages of the process and encourage the acquisition of new awareness regarding environmental and other situations: first, the photographs produced by each participant in response to specific questions, formulated participatively, once selected according to personal criteria, can be shared and discussed in group contexts where everyone's ideas can circulate freely thanks to the mediation of a facilitator (Wang, 1999) and the valuable presence of photographic support, which supports the verbalization of articulated thoughts and the free circulation of ideas (Wang and Burris, 1997). The photographic content can then be accompanied by captions that allow the communicative intent to be focused, made accessible to different audiences in the form of exhibitions, posters, photographic catalogs, brochures, and more (Latz and Mulvihill, 2017), in order to disseminate documentary materials and enter into dialogue

with the wider community. This experience can foster intergenerational exchanges between adults and children, as well as activate collaborative processes capable of triggering significant changes in the context in light of what has been documented by the *insiders* of an experience.

In this sense, as noted by Sutton-Brown (2014), putting a camera in the hands of unheard people can generate a paradigm shift capable of transforming those who are not very involved in the management of environmental issues into active subjects empowered by the possibility of using tools to document experiences or situations from their own point of view, which are then observed, analyzed, and discussed in a group, exploring meanings and promoting awareness that seemingly individual issues can actually affect everyone.

It is therefore a methodological process that guarantees self-determination, critical reflection, and artistic, personal, and political expression (Wang and Burris, 1997; Punch, 2002; Sutton-Brown, 2014), which are essential in taking responsibility for complex dynamics such as those related to ecology. Furthermore, consistent with the findings of research conducted by Shields and colleagues (2023) exploring creative forms and tools for child participation in preserving ocean biodiversity, photovoice appears to be an appropriate tool in this regard as it is based on child-led processes aimed at protecting environmental justice through access to information mediated by different codes of expression, such as the production of photographs and participation in roundtable discussions rather than information sessions, involving children and adults in creative experiences that promote two-way communication where the goal is to learn from each other and develop practices in light of lived experiences (*Ibid.*). Furthermore, some research found in the literature has involved the use of photovoice with young people and adults in order to co-construct environmental awareness aimed at conserving the biodiversity of the places closest to them (see, for example, Rivera Lopez, Wickson, and Hausner, 2018; Enloe *et al.*, 2021; Fiorella *et al.*, 2023) highlight that the use of artistic and participatory tools, such as photography in environmental research, are powerful tools for reducing the distance between researchers and other participants in the process, empowering all actors involved, improving conversations in a creative, harmonious, and inclusive way, and encouraging deep reflection aimed at transformative actions (Pröpper, 2017).

As described above, the combination of active, participatory, and collaborative learning methods can improve knowledge and skills in the field of biodiversity (Ramadoss, 2011), allowing children to define the meanings and characteristics attributed to the concept itself in a situated, personal, and active way (Lindemann-Matthies, 2009). From this point of view, science

education in the broad sense should be oriented precisely towards investigation and action, in order to promote a deeper understanding of the surrounding natural environment: in this sense, the various actions envisaged by *photovoice* appear to intercept these dimensions, promoting, as we have seen, personal engagement and deep reflection starting from the various activities in which it is possible to take part, which prove crucial in allowing even the youngest children to play a proactive role in observing environmental relationships and in co-constructing greater ecological awareness: Schlosberg (2007) argues in this regard that environmental justice should make visible the values and perspectives of those who pass through everyday spaces and places, highlighting, in this case through collections of images and words, those aspects that matter in generating change.

This focus allows us to broaden the spectrum of environmental and social justice, which shifts from being an individual issue to a collective one, recognizing that even the most silent groups, which are often those that suffer collective disadvantages, have the right to enjoy rights, exercise abilities, and take part in social movements that start from the bottom up, such as in educational contexts and outdoor spaces closest to them. It can therefore be said that if the learning model implemented is classical and standardized in nature, without inviting children to explore, observe, document, and collectively reflect on the most immediate biodiversity, which can be found in the living and real contexts that belong to everyone's daily life, then the knowledge gained will appear limited (Katili *et al.*, 2021) and less deeply rooted, as will be their critical awareness, which is necessary to generate significant changes in everyday practices: it therefore seems important to offer heterogeneous learning methods and styles precisely to inspire students to feel themselves part of that situation which, through their personal contribution, can be changed, since the sense of intimate participation with the living world combined with reflective processes such as *photovoice* can facilitate the development of ecological awareness (Guerra, 2020; Mortari, 2020) to rethink relationships with the world that nurture critical thinking (Mortari and Silva, 2018). Therefore, in light of the research found that implements the methodology purely with adults (Rivera Lopez, Wickson, and Hausner, 2018; Enloe *et al.*, 2021; Fiorella *et al.*, 2023), *photovoice* appears to be a promising approach for children as well, as it can foster a greater understanding of human-ecological relationships, promote behaviors aimed at conserving biodiversity within complex and local systems (deHaan, 2020), and allow for analysis of the impact of ecosystem changes caused by our actions on the well-being of our localities.

Conclusion

The way in which people develop their understanding of biodiversity should be a key issue for transdisciplinary research, given the pressing need for environmental conservation (Parreño *et al.*, 2022). As mentioned, national and international literature, as well as some documents (1989, 2015, 2022), highlight the fact that exercising the right to participation of younger people can promote human rights-based approaches in environmental policies, emphasizing the duty to recognize the proactive contribution of children to environmental sustainability and justice as an important means of civic and political engagement. Therefore, their point of view should be considered in the design and implementation of measures to address the environmental issues that are shaping their lives, through the promotion of participatory tools and approaches such as photovoice, which has the potential to encourage active engagement through the implementation of observational, documentary, collaborative, and transformative processes, which are more necessary than ever to promote renewed environmental awareness and enable participation in the actions for change that should affect our society.

In this sense, protecting the right to be heard can help empower those whose interests are not currently being met and represent the values of transformative sustainability, recognizing different ways of producing knowledge that are too often underrepresented in decision-making processes, encouraging sharing, imagination, and creative activation (Shields *et al.*, 2023), which are more important than ever to develop a deep understanding of the decisions that need to be made to ensure a better future for the planet and its people.

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This volume explores biodiversity education as a key dimension of contemporary responses to environmental and social transformations. It stems from the work of the BEAT—Biodiversity Education and Awareness Team research group, working on behalf of the NBFC—National Biodiversity Future Center on initiatives in biodiversity education and training. It draws on interdisciplinary collaboration between the pedagogical and biological sciences and is grounded in the recognition of biodiversity as essential to ecosystem functioning, climate resilience, and more-than-human flourishing, as well as in the growing need to develop educational perspectives and practices capable of fostering awareness, engagement, and responsible relationships with the living world.

The aim is to present the conceptual framework within which an approach—in many respects unprecedented—to education for and about biodiversity is situated, exploring its theoretical foundations and methodological considerations in depth. By focusing on potential topics of interest or categories useful for orienting perspectives, the contributions discuss theoretical assumptions for addressing biodiversity from a pedagogical standpoint, insights into the animal and plant worlds, and methodological aspects useful for designing educational settings.

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