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CHILDREN, EDUCATION AND NATURE-BASED SOLUTIONS: RESEARCH REVIEW REPORT

Jeppe Læssøe, Sally Anderson, Gertrud Lyngen Esbensen, Anne-Caroline Prévot, Léo Martin, Simon Benateau, Sebastien Turpin, Marcus Hedblom, Fredrika Martensson, Åsa Ode-Sang, et al.

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REGREEN
NATURE-BASED SOLUTIONS

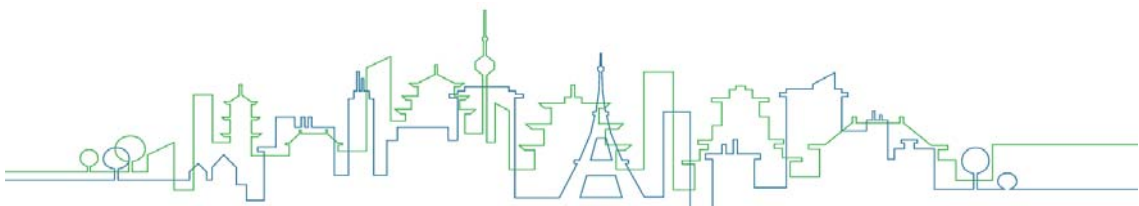
Fostering nature-based solutions for equitable, green and healthy urban transitions in Europe and China

Deliverable N°5.1.

WP N° 5: Education, participation and awareness

CHILDREN, EDUCATION AND NATURE-BASED SOLUTIONS: RESEARCH REVIEW REPORT

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EXECUTIVE SUMMARY

This report is written by scholars from WP5 as an internal REGREEN report with the aim of enabling knowledge exchange and development within WP5 as well as between WP5 and the other WPs in REGREEN.

The overall aim of WP5 is to investigate how children growing up in diverse urban environments perceive, access and use nature, and to research and develop educational programmes, tools and approaches that raise their awareness of, and participation in, NBS as vital resources for sustaining urban life.

The ambition of including children and education as part of NBS research is quite new and, for that reason, we approach it in an open and explorative way. It means that this report does not present a joint conceptual platform or protocol. Rather, it introduces different existing research perspectives, and summarizes knowledge from each of them, of relevance for our joint topic. By bringing our diverse theoretical as well as empirical knowledge into play across tasks, and importantly, into play with new research insights from our collaboration with the ULL's, we expect to be able to crystallize new knowledge on the potentials of the interplay between education and NBS.

Summarizing a report is typically a matter of condensing the key conclusions from the already presented analyses. However, in this case the explorative and introductory character of the chapters makes the following summaries of each of them more like appetizers indicating their content.

In the first chapter, Sally Anderson sketches out a tentative conceptual framework and a set of key questions for exploring 'children's interaction with nature'. Inspired by Ingold, she conceives learning as a matter of attending and education as an act of world-making that includes fashioning a viable way forward that includes both change and continuity. In our challenging times, this approach opens for foundational questions about the role of education and point towards the need for rethinking. In relation to REGREEN and NBS, such rethinking includes critical as well as explorative reflection on how we conceive 'children', 'nature' and 'interaction' when we talk about 'children's interaction with nature' (the issue of task 5.1). The chapter concludes with three specific research questions of relevance for WP5's work on education, awareness and participation in relation to NBS.

The report's second chapter is authored by Anne-Caroline Prévot, who, like Sally Anderson, addresses the issue of children's relations to nature, however in this case with a particular focus on experiences of nature (EoN) in current urban settings. Global urbanization and modern lifestyles tend to reduce urban children's opportunities for experiencing nature in their everyday life settings, at the same time as children to a lesser degree are scaffolded in ways that contribute to their experience of nature. Under these conditions, nature runs a risk of disappearing from urban citizens' visions and expectations for a good life. Drawing on research from her own institution (MNHN), as well as contributions from other scholars, Prévot documents that experiences of nature (EoN) in everyday life influence knowledge on bio-diversity and nature conservation, as well as engagement in environmental issues. Furthermore, research has explored multiple benefits of EoN for children. The chapter concludes by relating the issue of EoN with MNHN's ongoing research as part of REGREEN.

The third chapter, written by Léo Martin, Sébastien Turpin and Simon Bénateau, expands on the work of MNHN by presenting the Vigie-Nature-Ecole Citizen Science protocol. Developed by MNHN prior REGREEN, this protocol will be tested and elaborated during the course of the REGREEN project. Vigie-Nature Ecole aims at supporting and furthering schoolchildren's understanding of the impact of human activities and global changes on ordinary biodiversity. As such it is an example of Nature-

based Learning (NBL), which may help urban children reconnect with nature and, with this, motivate them to attend and learn from school-based NBS projects.

In the fourth chapter, Gertrud Lyng Ebsensen presents and discusses research on Nature-based Learning (NBL) with specific focus on the potentials of strengthening children's learning motivation and outcomes by applying digital technologies as learning tools in NBL processes. The chapter is partly based on existing research literature and partly on inspiration from Ebsensen's ongoing research into ways of applying digital technologies as educational tools for scaffolding children's learning to see nature. To conclude, Ebsensen introduces several ways of working with digital technologies in NBL and provides a list of potentially relevant apps.

The fifth chapter, authored by Fredrika Mårtensson, Åsa Ode-Sang, Björn Wiström and Marcus Hedblom from SLU, introduces their work with landscape laboratories and children's play-scapes. It focuses on the different qualities that various types of natural vegetation offer for children's play, learning and well-being, and explores potential ways of co-creating urban nature for and with children. Drawing on research in environmental psychology, the authors highlight the importance of nature for children's well-being, yet argue that as long as nature is not defined and biodiversity not quantified, it remains difficult to compare children's interaction with nature across locations. For this reason, the SLU research team is working to map children's play spaces through detailed exploration of the particularities of nature that support children's play. They are also working to find suitable mapping/monitoring methods for biodiversity in such play-biotopes that also are cost efficient and easy to monitor without major knowledge of species. The chapter concludes with a tentative suggestion for carrying out such mapping/monitoring and a state of the art presentation of methods for involving children in creative processes of co-design of play-biotopes. In this, they touch upon the issue of children as agents in the development of NBS.

In chapter six, Jeppe Læssøe addresses both the potential of citizen science (cf. chapter 3) and the potentials and challenges of involving children as agents and learners in NBS (cf. chapter 5). He differentiates between educational approaches to citizen science and explores opportunities for combining citizen science with action-oriented environmental learning. In this, he opens for expanding nature-based learning through citizen science into learning by participating in the development of NBS in children's own living areas.

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1. CHILDREN, EDUCATION AND NATURE BASED SOLUTIONS: REVIEW REPORT

1.1 Introduction

This research report, the first deliverable from Work Package 5 – Education, Participation and Awareness – is for internal use in the consortium. It introduces different theoretical and disciplinary perspectives, and empirical knowledge on our joint topic, to partners in WP5 and REGREEN partners not affiliated to WP5.

The overall aim of WP5 is to investigate how children growing up in diverse urban environments perceive, access and use nature, and to research and develop programmes, tools and approaches that raise their awareness of, and participation in, NBS as vital resources for sustaining urban life.

That partners in WP5 have quite diverse disciplinary and theoretical backgrounds, as well as diverse research interests is reflected in the organization of tasks, which are aimed at exploring and developing these different aspects of the overall topic. As this report comes at an early stage of the project, and with work delays due to Covid-19, we have not tried to produce a joint theoretical platform but rather expose each other to theories and methodologies we each bring to the conversation, and through this enabling and qualifying interdisciplinary dialogue and enhancing the coherence of the WP. Thus, rather than looking for what we have in common from the outset, we are exploring new and potential innovative connections between children, education and NBS in what may be described as a ‘diffracting’ process. This involves searching in different directions, creatively opening for new connections across differences, and exploring different ways forward (MacLure, 2015). We will identify and work with these differences and potential connections in our joint process in WP5 in the coming years. By bringing different theoretical and empirical knowledge into play with each other, and importantly also with new research insights from our collaborations with the ULL’s, we are expecting to crystallize new knowledge on the potentials of interplays between education and NBS.

Research in education, participation and awareness belong primarily to the social sciences and humanities. This is reflected in WP5 by partners trained in psychology, anthropology, digital design, communication, and pedagogy. That we focus on nature and NBS is reflected by partners trained in biology, landscape ecology, and environmental psychology. In that REGREEN’S interdisciplinary dialogue, within WP5 and with partners in other WP’s, includes non-academic partners, we have worked to provide a clear and readable introductory report that enables and enhances dialogue among all participants in REGREEN.

The report also serves as a frame of reference for collaboration with ULL’s and for empirical work in their settings. It is a collaborative point of departure that we can relate to, discuss and elaborate during our work in the coming years. Finally, we expect the contents of this report to be helpful later on for academic writing and publication.

In the first chapter, Sally Anderson sketches out a tentative conceptual framework and a set of relevant questions for exploring ‘children’s interaction with nature’. This is followed by two chapters from scholars affiliated with the Muséum National d’Histoire Naturelle (MNHN) in Paris, who have

over the last many years worked to provide schools and children with opportunities to learn more about their local green environment. The first of these chapters, written by Anne-Caroline Prévot, addresses like Anderson the issue of children's relation to nature, however here with a particular focus on nature experiences in current urban settings. Prévot's chapter provides background for the third chapter in which Léo Martin, Sébastien Turpin and Simon Bénateau introduce the Vigie-Nature-Ecole Citizen Science protocol, earlier established by MNHN and now to be tested and elaborated in REGREEN over the coming years. The Vigie-Nature Ecole protocol is an example of Nature Based Learning (NBL), which makes sense for linking education and Nature Based Solutions (NBS). In the fourth chapter, Gertrud Lynge Esbensen introduces NBL research with particular focus on the potential of strengthening learning motivation and outcomes by applying digital technologies as NBL tools. The fifth chapter, by Fredrika Mårtensson, Åsa Ode-Sang, Björn Wiström and Marcus Hedblom introduces their work with play-scapes and landscape laboratories that focuses on the play quality that different types of nature/vegetation afford children's play, learning and well-being. They also discuss the co-creation of urban nature for and with children. The participatory design of this work and its emphasis on children as agents and as active learners, prefaces the explicit focus of the sixth chapter by Jeppe Læssøe. He introduces different approaches to citizen science and explores possibilities for combining citizen science with action-oriented environmental learning. Læssøe explores ways of expanding nature-based learning in processes of citizen science to include learning by participating in developing NBS in the areas in which children live.

2. CHILDREN'S INTERACTION WITH NATURE: IMAGINING, NARRATING, AND INSTITUTING RELATIONS

Sally Anderson, Aarhus University, Denmark

2.1 Introduction

Task 5.1 'Children's interaction with nature' (REGREEN WP5) involves gathering, reviewing and compiling comparative data on how children, growing up in different urban environments, perceive, access, use, and experience something called 'nature.' Rather than taking 'children' as a generic category, our aim is explore and draw attention to differences among young people – cultural, socio-economic, physical differences, different physical environments in which their lives unfold, and how they are differently positioned – conceptually and socially – in the different ULLs as family members, minors, learners, social agents, citizens and more.

The purpose of this chapter is to sketch out a tentative conceptual framework and a set of relevant questions for exploring 'children's interaction with nature' – a rather vague phrase that begs many questions. Understanding children's interaction with nature involves exploring the key concepts – 'children,' 'nature' and 'interaction' – how these are given meaning and deployed in research as well as in different situations and localities. Second, it involves attending to the moral narratives and overarching worldviews through which perceptions of 'nature' are presented and made to matter for children. Third, it involves investigating the various ways children's lives are instituted through social and spatial organization, societal institutions and policies.

In sum, it involves attending to how a child's relationship with 'nature' is imagined, narrated, instituted and experienced by the children in question. This explorative focus is complicated in REGREEN because 'nature' is not just nature, but rather systemically linked natural processes that perform as NBS (NBS) to environmental disruptions potentially created by humans. How children 'interact' with NBS and how NBS are imagined, narrated and instituted for children remains to be found out. How we chose to animate abstract ideas of NBS and ecosystem services for children requires choices grounded in how we hope they will come to envision and relate to 'nature' and 'the world' for human survival.

2.2 Attending to the world that warrants our imaginationⁱ

Efforts to fashion sustainable, viable and livable cities through NBS that transform urban ecology are acts of *world-making*. Establishing NBS in particular localities includes reworking technologies, business concepts, policies, aesthetics, moral ideologies, knowledge regimes and pedagogies of relatedness. Refashioning urban landscapes to enhance ecosystem services thus affords opportunities for re-imagining the 'world' and the place of 'nature' in this world. NBS themselves and the many-faceted efforts to establish them have pedagogical potential for reshaping our understandings of human and non-human relations in the worlds we inhabit.

In that all acts of world-making set out problems of attending and figuring out what to do next (Varenne and Koyama 2011), world-making at all scales goes hand in hand with *learning*. Drawing on Gibson, Ingold argues for an understanding of education as 'the practice of attention' and learning as the 'education of attention' (2001: 113-114). Writing against a dichotomy between knowledge as information (acquired competence) and human beings as information processing devices (innate capacities) from classic cognitive psychology, Ingold argues that human knowledge is generated through emergent processes of attention and enskilment. Education will thus always be more than

the authorized transmission of information from one generation to the next, in that processes of attending and enskilling are carried on across generations, as new generations grow into and beyond the wisdom of their predecessors (Ingold 2017). In sum, what each generation contributes to the next is not “an accumulated stock of representations but an education of attention” (2001:114).

For Ingold, *attending* involves *listening, caring, waiting, being present, and going along* with others. It involves *corresponding* with others, in the sense of inhabiting the same life space and undergoing common experiences (2001: 114). Although he views each human being as a “center of awareness and agency in a field of practice,” Ingold, notes with Dewey that the “*continuity of the life process is not individual but social; “education in its broadest sense ... is the means of this social continuity of life”* (2017, my italics). Thus, education goes on wherever and whenever life goes on.

This view of education shifts focus away from the authorized transmission of information and testing of knowledge and raises questions of the socialities and relationalities of learning and enskilling across generations. With regard to NBS, we might consider how we could practice education as an ongoing intergenerational process of attending, and how we might scaffold emergent processes of enskilment. This perspective does not point to new ‘adjective-driven’ curriculum add-ons (environmental, sustainability, sustainable development, nature, conservation, ecological, place-based education) (Jickling and Sterling 2017: 3). Rather it points to exploring ways of seeing NBS as acts of world-making that afford pedagogical opportunities for educating the attention and enskilling across generations.

2.3 Learning to learn – change and continuity

American anthropologist and educator, Jules Henry argues that “learning to learn has been and continues to be our most formidable evolutionary task” (1965: 283-84). As Varenne and Koyama note (2011), each new condition we make for each other – whether on a grand or mundane scale - requires figuring out what to do *next*. A central educational problem for survival is keeping abreast of change and dealing with unforeseen problems precipitated by new ideas, discoveries and solutions. Because human cultures tend to bind the intellect into particular patterns of thought, ways of knowing, kinds of ignorance, particular fears and anxieties, human methods and rates of learning never quite keep pace with the need to learn (Henry 1965). Keeping abreast of change thus also involves dealing with the cultural lag or inertia that makes most processes of change slow and uneven.

Another core educational problem is figuring out what to conserve while changing (Henry 1965). In educating new generations, questions of what to conserve and what to change are controversial, as people differently weigh values, knowledge content, morals and temporal ideologies of past, present and future according to their interests and ways of thinking. Some find existing educational stances, in line with dominant economic paradigms, beneficial to their current livelihoods. Others claim that these stances undermine the very habitats on which all rely (Sterling 2017). Modern institutions of childhood education are framed by national interests and tasked with preparing children for future lives ‘in the *existing* society.’ Thus they tend to be conserving forces, with set structures and authoritative expressions and inculcation of values, knowledge, moral and anxieties aimed at enabling novices to ‘fit themselves into’ what are perceived as *stable* societal arrangements (Jay 2003; Cf. Sterling 2017: 36). Of interest here is that the notion of ‘societal interests’ appears conceptually detached from larger environmental or ecological concerns.

Figuring out what to change and what to conserve is complex because processes of change and conservation are interlinked and embedded in conceptual, moral, political, social and economic arrangements. Efforts to *amend* social injustices are grounded in efforts to *preserve* robust democratic governance and human rights. Efforts to *change* urban landscapes by *conserving* ecosystems are entwined with *changing* perceptions and valuation of natural environments. Prompting urban

children to attend to natural surroundings as ‘ecosystem services’ can lead to (symbolic) *changes* in the roles children play in environment-oriented practices, even as a dominant ‘metaphysical’ of environmental mastery and manipulation is *preserved* (Bonnet 2015: 51).

Moreover, environmental projects like REGREEN frame and invest in change and continuity in specific ways. Establishing NBS for viable urban living highlights some domains of change over others. Routine or radical technological changes to remedy high priority concerns – mitigation of climate gasses, flooding, heat islands and air pollution – make conventional sense, even if politically and economically tricky. Corresponding changes – green policies, eco-businesses, sustainable energy and transportation, environment-friendly architecture and building materials – likewise tend to make sense within already existing worldviews and economic paradigms, and thus may not lead to any radical changes in these perceptions of the ‘world’ (de Pina-Cabral 2017).

Changes in other domains, such as urban educational landscapes, are less highly profiled, perhaps because they are of less political interest or more difficult to align with existing worldviews. While laying out multifaceted changes to advance NBS, projects tend to frame education (and children) as add-ons. Education is cast as a spectator sport rather than a central institutional player in ongoing explorative processes in which *all* are faced with questions of what to conserve/preserve and what to change. To echo a stock consumer trope, projects tend to overlook the multifaceted educational services of ecosystems services. Projects well geared to exploring new business opportunities are less well geared to exploring the educational opportunities afforded by NBS-in-the-making, or addressing questions of radical or routine change to urban education landscapes.

Given that children themselves are, in a sense, invaluable NBS, a question to explore here is how we might engage their education as an emergent process of attending. We might also explore the question of which changes to urban (eco)educational landscapes (temporal, spatial, physical) invite modes of attending, enskiling, perceiving, and habituating that craft NBS as common sense solutions, commonly valued, willingly maintained and innovatively tweaked as needed.

2.4 Perceived barriers to change

This lack of focus on educational change is not for lack of trying. Scholars from a wide range of disciplines have over the last seven decades produced an extensive body of philosophical, theoretical and pedagogical literature on ‘nature education’ in all its various conceptual trappings (Cf. Læssøe and other chapters, this report). Work in this field has clearly progressed, not least due to rapidly expanding interest in ecological and environmental topics and concerns in both education and the public domain (Jickling 2017:xiii). Yet recent work in this field expresses dissatisfaction with achievements to date and reveals a struggle to rethink the purpose and foundations of education (Bonnett 2004; Kemp and Frølund, 2015 Jickling and Sterling 2017).

Scholars in this field share a common experience of ‘cultural lag,’ the experience that dominant worldviews throw up conceptual and practical barriers to change (Bonnet 2004; Johannesdottir and Thorgeirsdottir 2015; Jickling 2017). To the question of what prevents accumulations of environmental knowledge from developing into action and change (Frølund 2015), many scholars point to the power of deep-seated cultural orientations. In arguing for radical cultural change, Bonnett (2015:11) recommends relinquishing the ‘hidden metaphysical orientation of manipulation and mastery’ underlying the present environmental crisis and embracing an understanding of mutually sustaining human-nonhuman relations. Sterling (2017: 7) argues that instrumentalist views of education proffered by neoliberal ideology are maladaptive to the global systemic issues that shape our future. Frølund (2015) calls attention to the force of dominant ‘design ideas,’ *both* those that link ‘progress’ to human mastery of nature, *and* those that envision a stable and ‘pristine’ nature, untouched by

humans or modern civilization. Still others argue the need for threading new paths between unproductive ideological and theoretical oppositions, e.g. the futile polarity between scientism and fundamentalist religion (McCormick 2015) and equally futile rivalry between social constructivism and positivism (Bonnet 2015).

Scholarly disputes with hegemonic worldviews illustrate that the human task of 'learning to learn' for survival is never easy or straightforward. As such, change is always grounded in forces of cultural habituation, contestation over what to conserve and change, and an inevitable ignorance of emerging conditions. More positively, change is grounded in self-changing human beings with the capacity to imagine the world as otherwise, 'the human capacity to attend to the world in a certain way, as a kind of going beyond' (Henry 1965:53; Rapport 2010:2-3).

2.5 Rethinking education: foundational questions

Scholars of environmental education - philosophers, sociologists, geographers and more – are often affiliated with educational institutions. Thus they tend to discuss education in terms of modern institutions of schooling, and not in the broader anthropological sense as set out in by Ingold. This is not to say that they do not think in terms of education beyond schooling, only that their main arguments address the kinds of education practiced in schools (cf. Levinson 2000).

Tasking herself with rethinking the purpose of education, Sisitka (2015) proposes linking education for sustainable development with a concept of the global common good.

The commons refer here to those spaces, resources, ways of being, and systems (e.g. the earth systems) that are shared by all. Commoning as activity involves individual and collective actions to take care of shared resources, ways of being, and systems in the interests of social justice and ecological care (Sisitka 2017: 65).

Encouraging us to think education in a global context, to imagine a commons share by all, this view of education challenges national education systems and their competitive emphasis on national identity and prowess in a 'knowledge economy'.

Sisitka joins other long-time scholars of environmental education, who are mounting serious critiques of the focus and purpose of education as a whole (Jickling 2017:xiii). Current efforts to remake education derive from decades of "sustained efforts to infuse educational systems with education for sustainable development, sustainability education and for longer still environmental education, nature education, conservation education," not to forget ecological education and place-based education (Jickling and Sterling 2017: 3). The feeling that achievements made by these 'adjective-driven' curricula have not been sufficient has led to a sense of something amiss at the core. Jickling (2017) notes that dominant educational trends tend to fail to address contemporary issues, e.g. the present environment crisis and alternative ways of understanding. This has led to proposals for remaking education, framing new visions and fundamentally rethinking the purposes of education in a global context of accelerated change (Jickling and Sterling 2017: 6).

Rethinking nature's foundational place in education involves deliberating on the human-nature relationship and how 'nature' should come to matter to children. Should the world-making practice of human education be grounded in environmental awareness, sensitivity, knowledge, skills and relatedness, and if so, is this best done by relegating 'the environment' to a few specific subject areas or making it a core fund of attention and knowledge in all subjects? Or should we perhaps refashion our terminology such that human being and action is part and parcel of any ecology and not at the center of an 'environing world.'

Jickling (2017: ix) poses general questions such as how to remake education, what is missing, what is worth knowing, what is of enduring value, how do we teach. Bonnett (2015:50) more specifically questions the wisdom of relying on familiar paradigms of ‘manipulation and mastery’ and continuing to treat environmental issues as a set of problems to be fixed – through 1) greater scientific understanding of natural processes and human impact on these, 2) technological innovation, 3) heightened moral responsibility, and 4) encompassing global economic frameworks. To develop sustainable habitats for humans and nonhumans and greater environmental justice for all, Bonnett suggests opening for radical cultural change in our conceptualization of nature, our relationship with and our valuing of nature (Bonnet 2015:50; Jickling and Sterling 2017:6).

The questions Bonnett poses in *Retrieving Nature: Education for a Posthumanist Age* (2004:10) are relevant for thinking about our approach to ‘education’ in REGREEN:

1. What understanding of nature and our relationship with nature and the environment should we invite pupils to participate in?
2. What environmental ethics should inform our approach?
3. What kinds of knowledge and understanding best illuminate our relationship with nature or the environment and the environmental consequences of our actions, including their ideological content?
4. What kinds of knowledge and pedagogy are appropriate in an area where many of the issues are considered controversial and yet where we are seeking to influence pupils’ actions?
5. How might any of the above require a redefinition of roles and ethos within the school as an institution and in its dealings with the community outside itself?

These interrelated issues inevitably raise further philosophical questions about the nature of ethics, knowledge, human consciousness and human relationships with the world (Bonnett 2004:10-11). They also raise fundamental questions about the nature of education, its spatial, social and temporal organization, and what, if any, relation ecology bears on citizenship (Valdivielso 2015).

2.6 Conceptual sketches

The tentative framework laid out here rests on a claim that implementation of NBS in urban settings potentially does more than just remedy specific environmental problems. As an act of world-making, NBS may have the potential to embed a wider transformation, at once technological, political, moral, social, aesthetic, educational and cosmological. Under the right conditions, NBS may augur in new habits of attentiveness to one’s environment and attunement to others, both human and non-human. Given thought, NBS may encourage an understanding of education –in both field and classroom – as an opening to life rather than an imparting of authorized knowledge. Finally, they may help work against ‘idealist fantasies’ that thought transcends existence, and thus inspire new understandings of education as a changing/conserving effort to engender viable forms of social life (cf. Ingold, 2017).

I have dwelt at length on education and world-making to frame how we might think about human interactions with nature, including humans who fall under the category children. As stated, the concept of ‘children’s interaction with nature’ that anchors Task 5.1 is ambiguous, with many possible references depending on how we conceptualize the three key concepts: children, nature and interaction, none of which should be given from the start. The aim here is to briefly sketch the contours of questions about what these concepts capture and denote in different situations, localities and conceptual traditions.

Children

The concept of *children interacting with nature* evokes many images. Depending on place, language, lifestyle, economic, cultural and institutional arrangements, not to mention one's own childhood, these may be images of *play*: catching fireflies, *work*: haying, *school*: science project bug-collecting, *leisure*: sailing dinghies in the bay, or *household tasks*: feeding chickens or watering tomatoes on the balcony.

However one imagines children's interaction with nature, it is important to remember that children, like adults, are individuals with very different lives (Freeman and Tranter 2011). Young human beings are not generic 'children' or Piagetian stick-figures, nor do they necessarily run around in well-bounded sociological segments (Anderson 2003a). As such, actual children are always somewhat at odds with the necessarily reductive psychological, pedagogical, sociological theories deployed to understand their lives. Despite this, there is a tendency to 'capture' children in categories wieldy enough to do the conceptual, educational or political work at hand (cf. McDermott 1993).

In recent decades, scholars have shown great interest in childhood. Much of this work references a 'new childhood paradigm' launched in the late 1990s by British sociologists aiming to reposition children in British society and in social analysis (cf. James and Prout 1997). The thrust of this paradigmatic shift has been to reconceptualize children as 'active' social actors, as social agents 'in their own right' rather than mere 'passive' receivers of adult cultural transmission and institutionalized regimes of socialization and enculturation. This rather belated analytical shift from 'passive' to 'active' children was long prefaced by a wide array of progressive, child-centered pedagogies, as well as ethnographic studies of children's lives, agency, acquisition and appropriation of cultural ways. To any who have had or worked with children, the assumption that they do not actively shape the world around them is absurd. If children were truly passive receivers, there would be little need to sequester them in institutions.

Looking back, it appears that Durkheim's understanding of education as "the influence exercised by adult generations on *those that are not yet ready for social life*" was widely shared (Durkheim 1956: 71). Understandings of children as 'tabula rasa,' not-yet-social, passive receivers of cultural knowledge and social mores, are likely survivals from earlier authoritarian regimes of domestication, where well-meaning reformists successfully relocated children from workplaces and streets to gardens, schools, and playgrounds. The paradigm shift addressed political and policy questions of childhood and of children's place in society, their role as human beings, persons, and fellow citizens whose lives unfold here and now and not at some future point.

Much work today focuses on children's participation in socialities of the moment (cf. Ochs and Izquierdo 2009), and as fellow citizens, albeit minors, their participation in public space and their contribution both symbolically and practically to policy-making. In this, some scholars have noted among municipal authorities and planners a limited capacity to envision and limited willingness to plan for all facets of all children's lives (Anderson 2003b).

A study of relevance to REGREEN discusses surveying urban planners in New Zealand to find out how they take children into account in their planning (Freeman and Tanner 2011:6). Most planners answered that they considered children when planning for education (schools, kindergartens, day-care and more) and for recreation (playgrounds, sports), noting specifically their planning for skate parks. Their answers raise important questions of representation, also with regard to NBS:

For what other sector of society would one 'minority' and highly gendered sporting activity be seen as meeting general social and sporting needs? Also, what other sector of society would have their needs ignored when planning homes, streets, roads, shops, health and leisure facilities, transport and infrastructure? (Freeman and Tranter 2011: 6)

The study also found that planners held rather simplistic notions of children. In relation to their

planning they imagined a homogenous, universal child, and assumed that boys of a certain age were almost definitely interested in skateboarding (Freeman and Tranter 2011:6). Freeman and Tranter argue against these generic notions.

Children are not like that; their lives are not like that. (...) Like adults, children reflect the infinite variety of life, culture, age, race, gender, experience, character, level of ability, likes and dislikes, and are differentially affected by the environments and processes of environmental change. In the city children do more than recreate and go to school; they use the whole city. (...) Space in all its variations – home, school, street, bus stop, shop, soccer pitch, playground, health clinic, library, garden, city centre, public square – to name but a few – forms an integral component of the child’s world. Thus children are differentially affected by the environments in which their lives unfold and by processes of environmental change (Freeman and Tranter 2011:6-7).

Freeman and Tranter’s view of children’s lives in urban settings speaks to REGREEN and our question of ‘children’s interaction with nature.’ It is important that we do not limit our imagination of where children might encounter nature to generic children or generic domains of recreation and education. If indeed, children use the whole city, how individual children encounter ‘nature’ and NBS around the city remains to be found out (cf. Chawla 2015).

Nature

‘Nature’ tends to be a more controversial concept than children. While most can agree on ‘childhood’ as a cultural construct, a child remains a fact of nature. As such, children – not yet social, cultured or adult - are easily naturalized and universalized. They are *apriori* and generically ‘child-like’ despite studies showing that ‘child-likeness’ comes in many forms and that some children are not very adept at being child-like (Anderson 2003b, cf. Ochs and Izquierdo 2009). Nature on the other hand – the nature of nature – has been at the center of reflection and debate for centuries. Different authors and disciplines draw different boundaries around nature. They do not always agree on where nature stops and starts, or what entities and places are natural enough to constitute nature. Some authors, confident that readers will ‘naturally’ understand, feel little obligation to define the concept of nature they draw on or describe specific natural environments in the localities they study.

In an article on children’s connection to and affective attitudes toward nature, based in a study of fourth graders participating in a mandatory environmental education program in Brevard County, Florida), the authors never specify what they mean by nature (Cheng and Monroe 2012). Instead, they deploy an array of rather diffuse terms: natural world, natural environment, non-human natural environment, natural areas, wild natural areas, nearby natural areas, gardens, and ‘outside,’ natural sounds, and that which is marked by greenness and preferably no trash. They also allude to non-human counterpoints, wild animals, plants, rocks, shells, and wildflowers, contrast wild and domestic ‘nature activities.’ Such vague usage affords little understanding of actual natural environments, creatures, plants or activities specific to Brevard County and of relevance to different children’s lives. While this is perhaps an extreme example, the general problem is a tendency to use abstract notions of ‘nature’ as stand-ins for specific features of a local environment. While we may learn that children hold positive ideas and attitudes about ‘nature,’ we remain in the dark as to whether they actually encountered ducks in a local pond or witnessed a thunderstorm under the dubious shelter of a towering elm.

One task in REGREEN is to understand how specific children interact with specific aspects of a natural environment. This entails reflecting on usage of the concept(s) of nature (across languages) as presented to children, and creating some clarity about what we, and others, take ‘nature’ to represent, in general, locally, and in relation to NBS. This means paying attention to the gaps between what people, including children, say about nature and how they engage with natural surroundings.

There is much more to be said about the concept of nature than space allows. I close briefly with three problems. First, with regard to NBS it is not yet clear how the idea of ‘nature’ in processes such as ‘NBS’ or ‘ecosystems services’ will be presented to children, or how these processes will be narrated and animated. Second, it is not yet clear which specific parts of ‘nature’ primarily matter for children’s relationship with nature. Third, it is not clear exactly what form of relationship children are expected to forge with nature.

As far as I can tell, this is because no one yet has a clear answer. Recent work by environmental philosophers suggests that ‘nature’ is presently undergoing a conceptual overhaul with the aim of transforming the human-nature relationship to ensure a more viable future (Bonnett 2004; Kemp and Frølund 2015; Jickling and Sterling 2017). Conceptual work is also being carried out to better understand how nature is established as a human reality (Bubandt et al. 2003), and how to animate nature for humans prone to ‘ecological psychic numbing’ (Bai 2009). Scholars are also grappling with dialectics between nature as fact and nature as imagined, between nature as discourse and nature as matter, between nature as ‘scientific’ fact and nature as a ‘transcendent other’ (Bubandt et al. 2003; Lysgård and Fjledsted 2015, Bonnett 2015).

This philosophical world-making is theoretically stimulating and of utmost import. Yet how the ideas, stances, and urgencies this work embraces will percolate into schools and other forms of childhood education is not clear. Most likely, it will happen eclectically because, in a sense, we are all grasping at straws. As such, our work on education, awareness and participation with regard to NBS will be improvised forth – checking what is possible, evaluating what is viable, considering how best to attend and enskill, narrate and animate, and pondering how exactly to establish nature as a human reality – for young and old.

Interaction

The term interaction in ‘children’s interaction with nature’ implies a dyad comprised of a child and a physical element (or concept) of nature. While classic social interactionists have primarily focused on human interaction (Frake 1964; Goffman 1965; Sachs 1984; Kendon 1990), this rich field of minutely detailed observation and analysis of many different interactional genres may prove extremely useful for investigating how children interact with various artifacts and presences of the natural world. Drawing on Sacks (1984), it might be of particular interest to explore how children “do ‘being ordinary’ with regard to ‘nature’ – to better understand how children attend to normative modes of ‘interacting with nature’ as children, both individually and in groups of other children. Goffman’s work (1965) leads us to consider how people conduct interaction while on display in ‘public space,’ the kind of space in which most schoolchildren find themselves emplaced for many hours each day. Frake’s work (1964) points to the importance of ‘knowing how’ to do things in particular localities with particular kinds of people. It thus allows us to reflect on how different social domains may require specific knowledge of the modes, graces and discretions of interaction with nature practiced in these domains. Finally, Kendon’s work (1990) on the tacit, yet visible semiotics of movement and gesture, is an excellent starting place for researchers and educators to hone their skills of attending to the bodily action of children who are attending to ‘nature.’

While recognizing the import of paying close attention to the details of interaction – both human-human and human-nonhuman - in our work in WP5, we must also focus on the social organization, socialities and relationalities through which this interaction takes place. Urban children in particular are seldom in ‘pure’ dyadic relations with ‘nature.’ They are most likely to be in some form of public space, surrounded by unknown others, or flanked by family members, classmates and friends. In school, they move around in class-groups of 20-30 other children, flanked by teachers. Thus their ‘interaction with nature’ is inevitably inflected by ‘ordinary’ valued, and morally infused sociabilities and various relations – friends, classmates, insiders, outsiders, pupils, own or other people’s children – these sociabilities afford and constitute.

Since 2000, the theoretical and ethnographic body of work on sociality, sociability, and conviviality (cf. Toren 2012; Long and Moore 2015; Amit 2017; Anderson 2017; Remme and Sillander 2017), and on relations, practices of relatedness and modes of relating (cf. Carsten 2000) has grown rapidly. Too expansive to review here, given that urban children are rarely alone with/in 'nature,' it is imperative that we analytically grasp the empirical socialities, relationalities and disjunctures through which children come to 'interact with nature.'

Finally, we must also pay attention to how children and adults inscribe and narrate the social and moral significance of places where children are encouraged to 'interact with nature,' or to not interact as in places perceived to have little nature or nature of little matter. Here we might draw on Basso's perceptive ethnography, *Wisdom Sits in Places: Landscape and Language Among the Western Apache (1996)*, particularly chapter two: *Stalking with Stories*, which illustrates how adults telling stories imbue prominent features of the local landscape with moral lessons through which they 'stalk' wayward children.

2.7 In conclusion: children's interaction with children

WP5's wider focus on education involves exploring and designing educational programs and tools that encourage sustainable and viable human-nature relationships. Its focus on participation and awareness involves finding ways to help people grasp the everyday benefits of biodiverse, Nature Based Solutions in urban settings (and beyond), and gain a sense of their own capacity and responsibility for contributing to efforts to create more viable human-nature relationships.

This working paper 1) offers a preliminary investigation of a possible conceptual framework, 2) poses meta-questions regarding how we might proceed, and 3) offers sketches of three specific research questions of relevance for WP5's work on education, awareness and participation, specifically Task 5.1's exploration of children's interaction with nature.

How do researchers and educators imagine and conceptualize 'children' and 'nature' and the relationship between them, both as it is and ought to be?

In that cultural constructs are factual in their consequences, what implications and consequences do these conceptualizations have for/on children's engagement with NBS?

How do educators narrate and animate this relationship for children?

Which media, genres, characters, affective strategies, moral undertones and scare tactics are adults deploying to cause thought, reflection and moral stances toward nature?

How are city planners and educators imagining and instituting interaction and relationships between children and nature?

Which policies, planning, institutions, learning environments, forms of participation, and everyday socialities, and relationalities shape and afford children's interaction with nature?

These questions are designed to openly explore the relationalities being constituted on an axis of children, nature and society.

In contrast to educational research that claims to know up-front 'what needs to be done,' education as viewed here is an emergent world-making process. Treading the 'right path' is never given but always emergent, and as such requires prudent and wise reflection and rigorous attention to detail. It involves stretching our intellects beyond existing arrangements, figuring out what to conserve and what to change, accepting that we might not get it quite right, and leaving enough moral, conceptual, technological and political wiggle room for further viable change.

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Notes:

¹ Taken from Christina Toren's article, *Imagining the World that Warrants out Imagination: The Revelation of Ontogeny* (2012) *Cambridge Anthropology*, 30(1): 64-79.

3. TRANSFORMATIVE EXPERIENCES OF NATURE FOR CHILDREN, ADULTS AND THE SOCIETIES

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3.1 Introduction

In Work Package 5, the REGREEN project aims at developing “educational programmes and tools for bringing knowledge, awareness and a sense of individual and collective agency to children”. A specific point of attention is the ‘experiences of nature’ of children and adults living in cities.

Indeed, increases in urbanization, both globally and in western countries, combined with spreading modern lifestyles are seen as sources of the extinction of nature experiences among populations (Pyle 1993; Miller 2005; Soga and Gaston 2016). The concept, “extinction of experience,” is built on the assumption that western children are growing up in environments where nature (mostly plants and green) is decreasing (based on biodiversity decline and urban designs). A subsequent assumption is that children are less frequently encouraged to experience nature due to the social norms and worldviews of modern societies (Escobar 2007). The phenomena highlighted by this concept are thought to cause children to integrate to a lesser extent nature in their conceptions of what is “normal” and “important” for them, which are at the core of their future conception of ‘the good life’. This shades into future adults paying less and less attention and take less care of nature, because it does not belong to their vision of a good life. In this, biodiversity has hardly deserved public interest. Peter Kahn (e.g., 2002) has proposed that, due to a so-called “generational environmental amnesia”, people from a given generation accept that the level at which they integrate nature into their conception of a good life (as young adult) is lower than the level in previous generations.

In all of these studies, the term “nature” is never clearly defined; it is often equated with “green”, “greenspace”, or “urban parks”. The same goes for the term “experience”, which is often reduced to “contact”. Clayton and colleagues (2017) explore in more detail what experiences of nature can be. They define an experience of nature as a process, in which an individual encounters one of several elements of nature. In their perspective, each human-nature encounter is different, depending on (1) the type of nature (2) personal characteristics (identity, personal history, mood etc.), and (3) social norms and representation of what could and should be considered an experience of nature. Finally, to become an experience, this encounter must have consequences, which may similarly concern (1) the individual, (2) the society and/or (3) the nature encountered.

3.2 Exploring the diversity of experiences of nature

Experiences of nature combine cognitive, emotional, sensorial and/or social dimensions. Cognitive dimensions are clearly very important in experiences of nature. Petra Lindeman-Matthies show for instance that children in Switzerland can increase their interest in common plants and animal after educational programs. However, *sensorial* dimensions may also take a prominent place in perceived connections to nature. For instance, M.X. Truong (2019) showed that in urban settings, smell can be very important for some people’s experiences of urban nature. In the specific context of an urban zoo, the sound of urban birds may also be important to some visitors, allowing them to enjoy their visit as

a specific exotic-but-not-too-strange experience (Colléony et al. 2017a). *Social dimensions* may also be very important in lending significance to experiences of nature. The American education scientist Louise Chawla repeatedly shows the role of role models (notably parents and other caretakers) in the persistence of nature experiences for children (e.g., Chawla 1998). In contrast, several studies explain children's lack of opportunity to play outdoor with the reluctance, or even fear, caretakers may feel toward these environments (e.g., Copeland et al. 2012). These examples underline the importance of intergenerational transmission – both pro and con - in children's experience of nature.

Studies suggest that embodied experiences of nature may afford much richer connection and knowledge of nature than formal education programs. For instance, Sarah Pilgrim and colleagues (2007) have proposed that everyday experiences of nature are more disposed than formal environmental education to explain what they called 'ecoliteracy' (i.e. knowledge of common plants and animals) among British people. Yet, experiences of nature may also be *vicarious*, through media, various kinds of literature, and the arts. A study of the significance of greenery in on line gaming shows for instance that World of Warcraft (c)'s gamers do indeed experience nature when playing (Truong et al. 2018). The coexistence of vicarious and direct experiences of nature remains therefore a tricky issue to explore in relation to the combined objectives of biodiversity conservation, connection to nature and human well-being (Truong and Clayton 2015).

Artistic creations occupy a specify place in these vicarious experiences. Indeed, they both reflect general representations of nature of significance in the temporal and social context of their creation, and can provide a certain type of nature experience for their public. Recent research strongly suggests a decrease of the diversity and richness of nature presented in artistic creation in the last decades. Kesebir and Kesebir (2017) show that common names referring to elements of nature have tended to decrease in popular English language novels, films and songs over the last 50 years. Through a survey of nature representation in Disney films, A.C. Prévot and colleagues (2015) show an impoverishment in the representation of nature over a 70-year period. In contrast, some artistic creations actively offer vicarious experiences of nature. *Children books* for instance are important media for transmitting world-views to young children, notably through the design of drawings. Medin and Bang (2014) show for instance cultural differences in the representations of natural landscapes in children books written by native and non-native Americans. *Theater shows* are also potential media for such transmission. For instance, in the magical show "Le Bruit des loups" © (<https://theatre-cite.com/programmation/2019-2020/spectacle/le-bruit-des-loups/>), a modern adult remembers his childhood in the forest, where he meets a wolf, a giant, a deer, a fox, and magical plants. The common imaginary forest present in European fairy tales is obviously present in this show, and provides a common ground of understanding for the audience.

3.3 Individually transforming experiences of nature

Louise Chawla has extensively studied the prominent importance of experiencing nature during childhood. She defines "significant experiences" as those which appear for children when they freely explore nature, most often with an adult considered as a role model (Chawla 1998) These experiences, which may also be negative, can include social involvement, family, play, etc (Chawla 1999).

In a similar vein, A.C. Prévot and colleagues (2016a) show that students (i.e. young adults) with the highest environmental identity (i.e. a measure of connection to nature) were those who reported having grown up in more rural settings, having gone out into nature most often, and having friends and relatives more aware of environmental issues. These results are consistent with the hypotheses

that connection to nature is correlated with (1) experiences of nature during childhood (see L. Chawla's work), (2) current experiences of nature, and (3) social identity regarding nature.

However, experiences of nature can be transformative during the adulthood as well. A.C. Prévot and colleagues (2018) have shown for instance that urban citizens who report having experiences of nature in their everyday lives, sometimes know more about biodiversity and conservation issues, and more often implement pro-biodiversity behaviors in their everyday lives. Based on an anthropological survey, A. Cosquer (2012) has shown that volunteers in a garden butterfly survey may progressively increase their knowledge of butterflies' ecology, as well as increase their interest in other garden species, and eventually modify their gardening practices toward more biodiversity-friendly practices. This result was recently confirmed through a quantitative survey of whole networks of volunteers in such a citizen-science programs (Deguines et al. 2020).

3.4 Experiences of nature, world visions and transformative changes in politics and urban planning?

In its global assessment, the International Platform for Biodiversity and Ecosystem Services (IPBES) claims that conserving biodiversity and achieving sustainable ways of life hardly need profound transformations of modern worldviews, values and paradigms (Dias et al. 2019). Transformative changes to modern societies can be achieved rather through cross-sectorial cooperation (Dias et al. 2019). However, unless involved stakeholders share common goals, definitions and/or mental models, such cooperation is difficult to implement.

One of the first common notions to consider is *biodiversity*. The term, "biodiversity" is defined in many different ways, even among scientific and experts. Biodiversity may refer to species, individuals and/or ecosystems (Convention for Biological Diversity); it can specify the importance of dynamic and evolutionary interactions between individuals, species and/or ecosystems; it can exclude or include domesticated species (i.e. crops, cattle, horticultural plants and pets); it can exclude or include humans. Despite this ambiguity, the term is widely used by the conservationist community, which sometimes complains about the general public's lack of knowledge regarding this notion, and asks for more "education".

Yet, recent studies in France strongly suggest that the definitions of biodiversity by scientists and the so-called "general public" (i.e. lay people regarding biodiversity) are not very different and might even enrich each other. First, a study of urban citizens encountered in a very crowded and mineral urban context (the Seine-Saint-Denis department, in the Paris region) has shown that they have relations with urban nature, and the diversity of these relations is similar to the diversity of visions in the community of scientists (Prévot et al. 2016b). Second, lay-people can actually define the term "biodiversity" in ways quite similar to scientific definitions (Levé et al. 2019). However, that some participants added to their definition a sense of urgency to act could be meaningful with regard to conservationists (Levé et al. 2019). Further, another survey of a sample of 4000 French adults showed that what they designate as a "natural area" may differ from the conservationists' vision (Colléony et al. 2017b), notably concerning private gardens. This study also showed that people who have grown up in rural areas are more prone to cite "countryside" as their favorite natural area; in contrast, people who have grown up in more urban settings are more prone to refer to urban parks. Note that all surveyed people were currently living in cities.

3.5 Conclusion – Experience of nature in the REGREEN program

In the REGREEN project, we will use the framework proposed by Clayton et al. (2017) to describe in detail the experiences of nature the children under study encounter. We will first assess the divergence and convergence of definitions of biodiversity among involved stakeholders (children, teachers, other adults in the schools, parents if possible). We will then survey children and adults throughout the implementation of citizen-science programs at school, in order to detail the dimensions of ongoing experiences of nature. In parallel, we will survey the vicarious experience of nature that children and adults gain through watching the magic show *Le Bruit des Loups* ©.

Throughout this study, we will explore whether and how links between sensorial and affective dimensions of experience and knowledge acquisition, for instance through citizen science or *le Bruit des Loups*, might enrich children's and adults' experiences of nature and help them deeply integrate particular values and worldviews. Further, we will ask how these experiences might help concerned people develop their personal citizenship and empowerment. Eventually, we will explore questions of governance and general worldviews and values in the concerned societies.

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4. SCHOOL AND CHILDREN INVOLVEMENT IN CITIZEN SCIENCE IN URBAN AREAS - AN EXAMPLE OF VIGIE-NATURE-ECOLE FOR REGREEN.

Léo Martin, Sebastien Turpin and Simon Bénateau, National Museum of Natural History, Paris, France

4.1 Introduction

In the current context of ecological crisis, the lack of personal involvement in issues of conservation and biodiversity is often mentioned. A number of studies point to a growing disconnection from nature (Soga and Gaston, 2016). Reconnecting means fostering emotional ties to special places (forests, parks, etc.) as well as a link with everyday nature. The Vigie-Nature École program for schools offers a solution to this disconnection.

Backed by the Muséum National d'Histoire Naturelle, the program is an offshoot of our broader nature-watch program Vigie-Nature. For the school program, we develop observation protocols that enable students to discover the incredible biodiversity surrounding them. By making observations, the expectation is that students will realize the importance of their daily actions and their own possible role in protecting biodiversity. The Protocols also provide an opportunity to broach threats to biodiversity more concretely. Lastly, our protocols enable students to collect data that are truly useful for scientists and that contribute to national databases.

Here we will present the Vigie-Nature Ecole program and how it is implemented within the framework of Regreen.



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4.2 What is Vigie-Nature-Ecole?

Vigie-Nature is a citizen science program aimed at better understanding the impact of human activities and global changes in ordinary biodiversity. To this end, volunteers give our researchers a hand by reporting their observations, which are carried out according to specific protocols.

Origin

In 2010, the Museum, in collaboration with Canopé Paris and Natureparif, explored the possibility of offering participatory science programs for schools, based on the Vigie-Nature program. In 2011, after these initial tests, it was decided to design a Vigie-Nature version specifically for use in school settings. In particular, this development was led by a life and earth sciences teacher in close collaboration with the French National Education Inspectorate Generals to ensure perfect integration with school curricula. Vigie-Nature Ecole was born.

Framework

Vigie-Nature École offers French schoolteachers the opportunity to monitor “common” biodiversity with their pupils by using scientific protocols. Any of seven lines of study are open to pupils from nursery school to secondary school: snails; pollinating insects; bats; earthworms; urban plant life; birds; and seaweed and shellfish.

For teachers, it is an opportunity to experiment with new, motivating, concrete and, should they wish, multidisciplinary activities. The protocols, developed by Museum researchers, are a way to learn about scientific methods through hands-on practice. Students observe and identify species, and thereby

learn the importance of collecting data under conditions that are both standardized (duration, surface area, time of year etc.) and documented (weather, type of terrain etc). The data they collect contributes directly to scientific research on biodiversity and how it is faring in a shifting global context. Results are collated and communicated back to the students in the form of reports appropriate for their age group, enabling them to assess their school or area's biological diversity. These resources prompt participants to investigate which actions might be taken to bolster biodiversity. This unique program, which has now reached a certain maturity, boasts a number of advantages for both educational and research communities in France. The overall program organization is summarized in figure 1.

Since June 2020, Vigie-Nature Ecole has made available an online data analysis platform called Galaxy-Bricks. Galaxy Bricks is a system that offers Vigie-Nature participants a simple tool to browse and exploit the databases of the observatory in which they participate. Thanks to a pedagogic interface, all observers have access to data manipulation, visualization and statistical analysis, which only researchers have been able to do until now. In addition to access to the data, Galaxy Bricks is a pedagogic tool for high school and university teachers who wish to discuss statistics in ecology with their students.

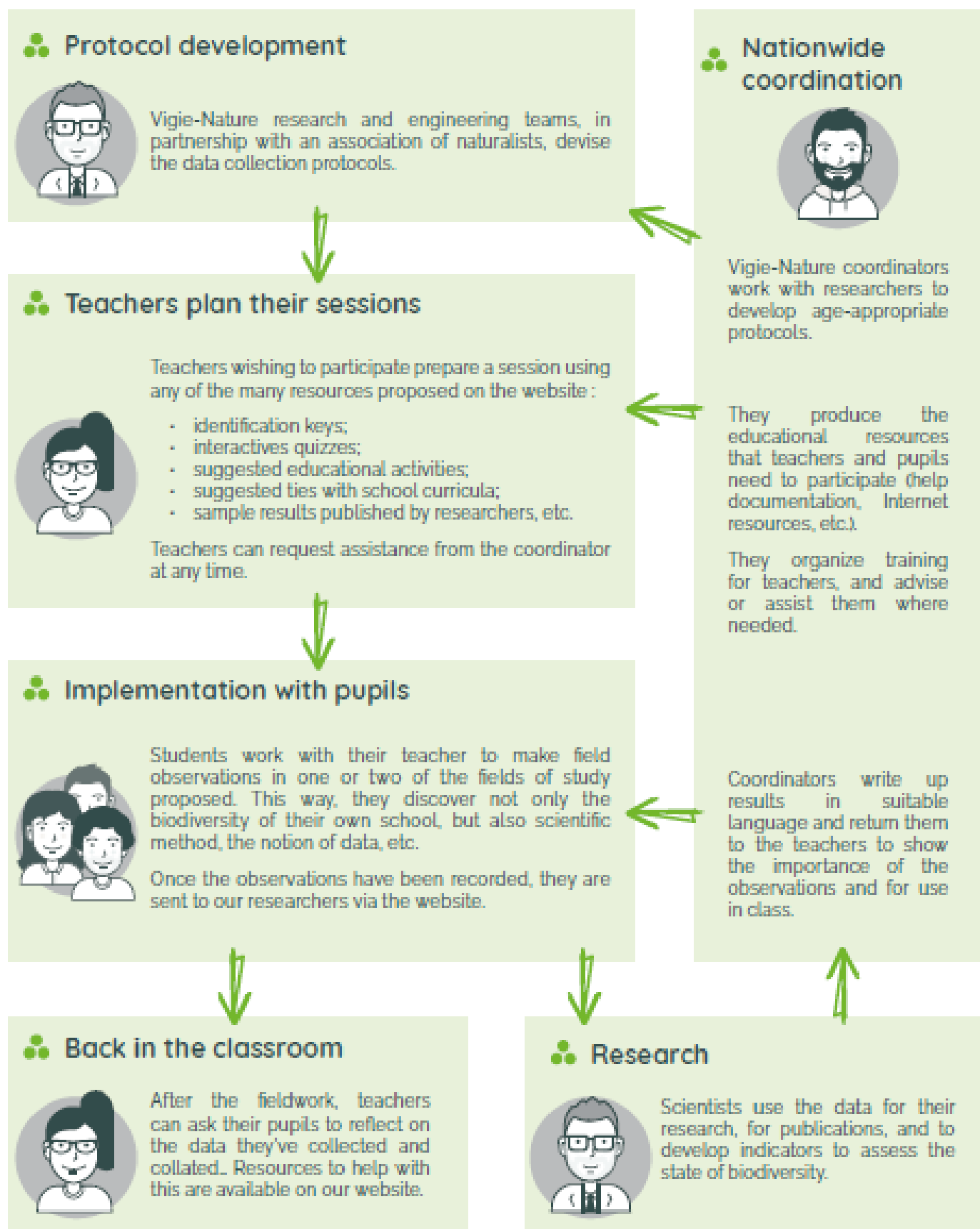


Figure 1: Framework and organization of Vigie-Nature-Ecole.

Overview and participant profiles

From the start, the number of participating classes that were submitting data grew at a steady pace, going from about 50 during the school year 2013-2014 to roughly 313 in 2018-2019 (figure 2). However, a survey of schoolteachers conducted in June 2016 revealed that half of the teachers who replied had carried out the activities with their classes but never submitted the data collected. Therefore, the number of classes that actually did the observations over the previous school year was roughly 600 (about 15,000 pupils).

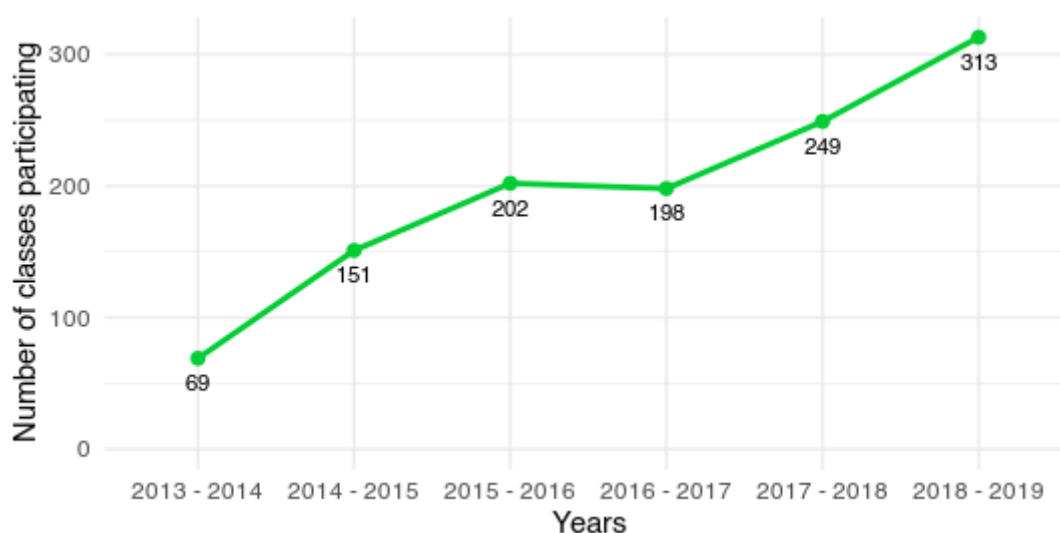


Figure 2: Evolution of the number of participants

A second study in didactics carried out in 2018 by Bosdeveix et al (2018) was interested in the motivations of teachers to participate in VNE. With more than 99 respondents out of 254 VNE participants, this study shows that one motivation is participating in a citizen science program. However, there is a significant gap in terms of actual contribution to research. Indeed, half of the participants report not sharing their data with researchers for various reasons (e.g. lack of time, computer difficulties, non-compliance with protocol, unreliability of data). This result seems to reflect a tension between the researchers' data collection objectives and the objectives of some teachers: the contribution to research is finally not so important for some, even though it is stated as an objective. Researchers point out that these tensions are certainly not always conscious; they may be due to the multiple constraints in the school context and lead some teachers to relegate the task of sending data to the MNHN to the background (Bosdeveix et al, 2018).

All educational stages are concerned, with most pupils in cycle 3 or 4 (age 10-11). Children in the first year of lower secondary (11-12) account for 26% of all participants. This can be explained by the suitability of the activities in terms of the existing science curriculum for this level (figure 3).

Nevertheless, it should be noted that the level of the classes participating depends largely on the field of study. Most of the classes monitoring pollinating insects using photography (Spipoll) are upper secondary, while most of the children participating in the garden birds program are in primary school (figure 4).

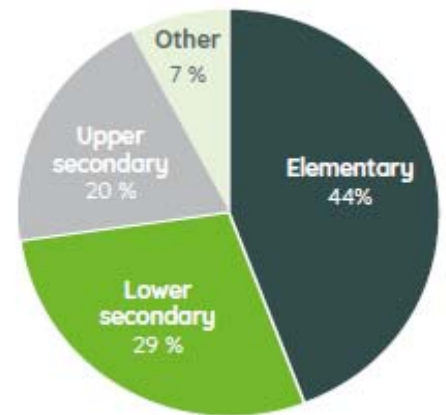


Figure 3: Academic level of participants

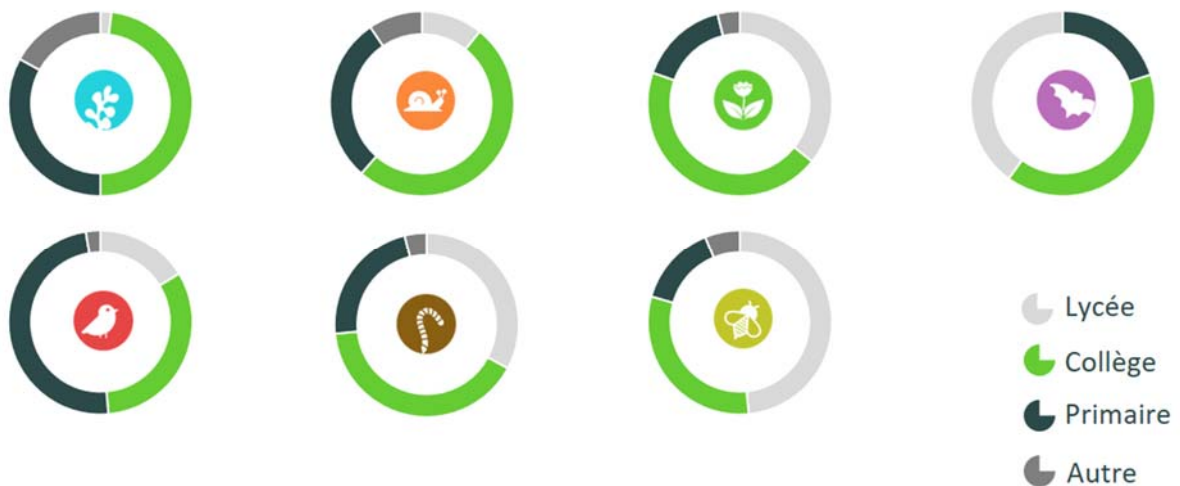


Figure 4 : Participation in protocols according to school level



Figure 5: Geographical breakdown of participants in France.

The distribution of classes enrolled in 2018/2019 reveals good overall participation, even if certain gaps remain. The teacher training that we provide with support from Inspectors General of National Education should enable us to fill the gaps in these geographic zones (figure 5).

4.3 The mobilization of Vigie-Nature Ecole in the European REGREEN program.

In the philosophy of Vigie-Nature Ecole, grounding talk in concrete local action is the number one key to raising awareness about the erosion of biodiversity. Taking students out of the classroom and into the field to learn about the diversity of species that live all around them is one way to reconnect them with nature before addressing the measures that must be taken to preserve it.

Indeed, biodiversity is one of the important elements of life science teaching, but other disciplines address this theme through the sustainable development approach. The notion of biodiversity is addressed throughout the school year so that pupils can, based on their knowledge, adopt a reasoned attitude and a responsible citizen's behaviour towards their environment.

However, tackling this theme is not always simple. There is indeed a great risk of limiting oneself to the issue of endangered species such as polar bears or orangutans. Although a source of concern, dealing only with these species will convey the message that the erosion of biodiversity is a distant issue with no immediate consequences for the lives of our students. This geographical remoteness may also make our students think that no action is possible at their level to preserve biodiversity.

On the contrary, going out with the pupils in the schoolyard and introducing them to the diversity of plants or pollinating insects helps, as a first step, to create a link between the pupils and nature. They will also be surprised by the diversity of species that can be found in a small space and that we come into daily contact with.

This postulate adopted by Vigie-Nature Ecole is particularly interesting with regard to the objectives set by the REGREEN program and in particular in WP5.

Indeed, the Museum wants to understand to what extent this participatory science program can contribute to reconnecting children with nature. In addition, the protocols are a real educational tool to enable pupils to inventory biodiversity in their school.

The observations made make it possible to compare the richness and composition of the facility's biodiversity with that of other facilities. These comparisons may lead students to consider what actions could be taken to promote biodiversity in the courtyard.

For this reason, we would like to involve teachers, students, management, green space managers and parents in a process of improving biodiversity in their school. We would like this inventory base to lead to biodiversity-friendly developments in schoolyards.

Actions can be very diverse and depend on the environmental, historical and architectural context of the school. This could include installing bird-nesting boxes, creating an insect refuge with wasteland, planting plants in tubs, setting up a vegetable garden. The most important intervention could be the depaving of a surface in the schoolyard. This could be done in consultation with IPR and WP3, Task 3.4. Other operations, such as securing green areas not accessible to students, could also be carried out and thought of in terms of psychosocial benefits for the school.

To conclude, to measure the effectiveness of these actions, the initial inventories will be compared with post-installation inventories to assess their effectiveness.

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5. DIGITAL TECHNOLOGY TOOLS FOR NATURE EDUCATION IN SCHOOLS AND BEYOND

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5.1 Introduction

Smart technology such as phones and tablets³ shows promising possibilities for education for sustainable development and thus it is plausible the same could be said for Nature-based Solutions (NBS). Over the last decade, researchers have explored the potential of smart technology in outdoor schooling. A growing body of research indicates that mobile technology can be used for facilitating access to remote places, increasing student interaction with natural surroundings, providing opportunities for location-based learning, as well as situated learning in nature and more (Shaal & Lude, 2015). Shaal & Lude also note though that many of the educators in their study were not aware of these possibilities (2015, p. 10166).

This chapter begins with an introduction to the field of children, technology and nature, followed by a clarification of the relations between the chapter's use of NBS education and education for sustainable development, environmental literacy and science learning more broadly. After a brief review of literature on technology use in outdoor education, I conclude by touching upon my own field research in a cross-disciplinary Danish research project entitled Natural Technology (Schilhab & Ebsensen, 2019) (<https://naturligteknik.dk/en/>).

In line with Shaal & Lude, our research also shows that those who use technology in nature-based learning (Chawla, 2018) are mostly frontrunners in Danish education (Schilhab, Ebsensen, & Nielsen, 2020, in Danish). More commonly, one finds an opposition between nature and technology, with children and youth urged to put away their phone and tablets and enjoy nature/ the outdoors instead (Anderson et al., 2015). A common understanding is that healthy and happy childhoods entail being and playing outside without the poor quality of experience that technology is thought to provide (Halldén, 2010, in Swedish).

These values are however neither universal nor independent of time. They can be traced back to the end of the eighteenth century, when a new way of perceiving the landscape emerged. From viewing the natural landscape as a place for production, people came to see it as a place for recreation, contemplation, and romance (Frykman & Löfgren, 1983, p. 51). Korsgaard et al. argue that during this period western educators began to idealize education for a sound soul in a sound body in healthy surroundings, and to ascribe thus value to outdoor life (Korsgaard, Kristensen, & Jensen, 2017, p. 279, in Danish). Such an idealization must be perceived in context, considering where and how people live in the different times and how their everyday life unfolds.

Today, the use of technology in relation to nature encompasses a wide variety of activities with various purposes in mind: orienteering, photography, exploring natural phenomena, looking up scientific findings, food gathering, learning, cultural dissemination, play, sports and so on. With smartphones

³ In the following, I use the term phones and tablets, instead of speaking about MED (Mobile Electronic Devices) even though I acknowledge that other devices such as handheld GPS devices, cameras, smartwatches, PDA's and so on, also can be used in technologically mediated teaching activities. I choose that in order to make the text more readable and due to the dissemination of smartphones in many societies worldwide.

one can measure tree height, lake size and distances walked; one can identify plants, trees and animal life, play games and do teambuilding activities and much more.

In Denmark there is an emerging tradition of outdoor education/nature-based learning, by some termed 'outdoor school' (Bentsen, Stevenson, Mygind, & Barfod, 2018) where focus is on direct experiences, bodily learning and on evoking the students' interest and curiosity (Bølling, Otte, Elsborg, Nielsen, & Bentsen, 2018; Christensen, 2015; 2019, in Danish). However, smartphones and tablets are seldom mentioned in Danish peer-reviewed literature on outdoor schooling.

Technology can, beyond a doubt, keep students from engaging with nature as well as take their attention from their surroundings. This, however, does not mean that the problem is the technology per se; it could be the way the technology is shaped or how it is used and fitted into the educational context (Aguayo & Eames, 2017). Thus I find it important to keep an open mind and explore how technology is actually being used in education to enhance environmental literacy.

5.2 Nature-based solutions and education

Literature on how Nature-based Solutions are being taught to students is as yet scarce. However, the UK Landscape Institute and International Institute for Environment and Development have created highly educational animations about why NBS are relevant (International Institute for Environment and Development, 2018; Landscape Institute, 2013) and these animations could be suitable as introduction into the topic. In addition, the project Scientix⁴ is currently developing learning scenarios that integrate Nature-based Solutions in classrooms.

Yet a vast amount of literature is in various ways aimed at documenting and proving that for children to grow up to be caring towards nature, they need to know about and experience nature first hand, i.e. not through technology (See e.g. Broch, 2005; Carlone et al., 2015; Skar, Gundersen, & O'Brien, 2016; Szczytko, Stevenson, Peterson, & Bondell, 2020). For example, professor Chawla states:

The environmental activists' stories suggest that when children have access to the natural world, and close family members encourage them to explore it and demonstrate by their own example that it deserves attention, children develop an eager interest in it. To turn this interest into activism, people need to build on this foundation through education, membership in organizations, or career choices. From their childhood experiences of free play in nature and significant role models, they bring to their adult work a legacy of memories, which affirm that the natural world is a place of such full and positive meaning that it justifies their most persistent efforts to protect it (Chawla, 2007, p. 161).

Here, learning about Nature-based Solutions is perceived as an aspect of acquiring environmental literacy. In the following, I explore educational practices aimed at teaching students about our surrounding world. In this I am inspired by technology-mediated practices in Nature-based Learning processes within Science Education, Environmental Education, Education for Sustainable Development, Nature Education, etc. because I see this as a first step towards more explicit learning about NBS.

⁴ <http://www.scientix.eu/da/pilots/nbs-project>

5.3 Part 1: Existing literature on technology use in outdoor education and environmental education

Technology use in education may be inscribed in a field of ‘mobile learning’. In overall terms, mobile learning is a growing and ever evolving field enabling situated learning and enabling what Aguayo et al. terms authentic learning experiences taking place across learning contexts (Aguayo, Cochrane, & Narayan, 2017; Aguayo & Eames, 2017). At present, mobile learning is being investigated for its potential to increase educational awareness (Uzunboylu, Cavus, & Ercag, 2009). Sharples & Pea list four good reasons for getting out of the classroom and using phones and tablets for learning (2014). First, when learning processes become more interwoven with everyday activities, these become a resource for learning and provide opportunities for problem-based learning. Second, learning processes become more student-centered and the teacher takes a more facilitating role. Third, learning processes in nature are contextualized and situated in time and place, and finally, when technologies work as intended, everyday natural interaction and situations become learning processes (Sharples & Pea, 2014). Because mobile learning does not necessarily take place in nature or merely outdoors, I think of mobile learning in combination with Nature-based Learning (Chawla, 2018) which does not necessarily include technology.

In the following I report from existing published cases with a focus on newer material (from 2015) due to recent developments in technological possibilities. This is meant to be a teaser for potential future studies.

Zimmerman et al. explore how mobile devices can support outdoor science learning (2019). They underline that play, sense-making talk and embodied interaction are all important aspects of informal learning, which complement other outdoor learning processes and create enjoyable experiences (Zimmerman et al., 2019). They have created two different learning courses in an Arboretum using a place sensitive app. Participants walk to posts (physical places), where content is transmitted on a phone or tablet such that specific learning activities are being pushed through the app. They present a case of a course that combines learning, embodied interaction and play:

After reading the science content from the iPad with his partner, Sebastian and his summer camp friends learned that Pennsylvania was covered in ocean and coral and other sea creatures, and these eventually created the limestone rock needed to form caves in the karst hydrogeological landscape. With this knowledge, Sebastian’s ideas about and relationship with his community changed. Learning that Pennsylvania was once home to the ocean and sea creatures encouraged Sebastian and his partner to engage in multiple role-play activities as they learned new content from the mobile system. These boys’ playful interactions did not detract from the scientific interactions. Sebastian, for instance, later shared scientific documentaries he watched at home related to the topic and engaged in science talk with his partner. We posit that these added to the learners’ positive experience in the Arboretum (Zimmerman et al., 2019, pp. 466-467).

Here the authors present a certain approach that highlights how they use technology to combine science teaching with time for free play, in a way that allows (younger) boys to immediately relate to their new knowledge by integrating it in their play.

Huang and colleagues have conducted a statistical analysis of how different learning styles including paper-based teaching material versus Augmented Reality-based teaching materials influence teaching

courses in Yehliu National Geopark (Huang, Chen, & Hsu, 2019). They show that Augmented Reality can improve learning performance and motivate students because they get immediate access to supplementary information. This last aspect is also mentioned in Anderson et al.'s study of a course module called 'Go with the flow' about local landscape hydrology, where some field groups used technology posted on blogs and webpages, while other groups mostly used traditional scientific media (Anderson et al., 2015). They report better learning outcome for the group using digital technology. One of the researchers made the following note in her journal:

The students carefully recorded and described a scientific experiment in detail, using photos and videos, with the intent that their parents (individuals completely unaware of the situation or methods being used) could understand what they were doing to discover something about the ecology of the region. Through communicating the step-by-step process of collecting and analyzing data, this experience served as a formative assessment of the students' comprehension of concepts being presented. Technology enabled the students to reach out and share their experiences with a broader audience, inspiring a more detailed and in-depth description of their learning experiences (Anderson et al., 2015, p. 12).

Technology's potential for fixating the seen and documented and thus potential for supporting the students' knowledge-sharing suggests interesting possibilities for students' learning processes.

Research from the German University of Education in Ludwigsburg is among the leading educational research in the field of technology use in Nature-based Learning. In the 'mobi-LU' project, a Delphi study was conducted in order to hear experts'⁵ experiences of advantages and disadvantages with using mobile devices in environmental education and education for sustainable development. Among other things, they conclude:

The challenge of adopting new technologies within a domain like environmental education, fostering experiential learning and practical actions in nature, would be to combine the strengths of the "real" and the "digital" world. This should be trained, and professional development for the educational staff or at least some type of guidance during the process of creating inspiring educational programs and activities supported by mobile devices seems to be needed (Shaal & Lude, 2015, p. 10166).

In another project, BioDiv2Go, researchers developed Geogames aimed at Education for Sustainable Development and biodiversity learning (Schneider & Schaal, 2018; Schaal, Schaal, & Lude, 2015).

The Geogames are constructed to lead players into nature supported by technology to foster connectedness to nature as the affective part of attitude towards nature. The role of the smartphone games is to structure the field experience, to enrich the location-based discoveries by providing multiple representations (audio, video, text-image combination) and by adding game-related enjoyment as a factor addressing basic psychological needs (Schneider & Schaal, 2018, p. 1598).

Their study finds that even short interventions like theirs provide an opportunity to foster increased nature-connectedness with regard to Schultz's (2002) term 'Inclusion of nature in self' (Schneider & Schaal, 2018, p. 1606). The study suggests that while enjoying playing games outdoors the student's sense of place attachments shifts because the gaming field becomes meaningful for the players. The

⁵ Twelve experts within the field of environmental science, pedagogy, technology and economics.

study also suggests that this effect is highest in students who initially felt most separate from nature (Schneider & Schaal, 2018, p. 1607). They argue further:

[G]eogames that refer to real places can be perceived as the link between knowledge transfer, inquiry-based learning and playing as an active form of entertainment (Kerres & Bormann, 2009; Prensky, 2001). Thereby, geogames in learning settings belong to the conceptual area of digital game-based learning (DGBL, Prensky, 2001). There is a body of evidence that DGBL approaches are suitable for knowledge construction (Anderson et al., 2015; Chang, Chen, & Hsu, 2011; Lai, Yang, Chen, Ho, & Chan, 2007; Li, Cheng, & Liu, 2013; Perry & Klopfer, 2014; Schaal, 2017), they can increase motivation (Chang et al., 2011; Ruchter, Klar, & Geiger, 2010; Tsai, Yu, & Hsiao, 2012) and environmental awareness (Bleck, Bullinger, Lude, & Schaal, 2012; Lude, Schaal, Bullinger, & Bleck, 2013; Perry & Klopfer, 2014; Schaal & Lude, 2015; Schaal, Grübmeier, & Matt, 2012) and they can foster a positive attitude toward nature (Crawford, Holder, & O'Connor, 2016; Schaal, 2017). Additionally DGBL enable students to experience fun and enjoyment during educational activities (Anderson et al., 2015; Cohen, 2014; Crawford et al., 2016; Schaal, 2017; Schaal et al., 2015) (Schaal, Otto, Schaal, & Lude, 2018, p. 215).

Here the focus is on motivating students to get outside, to learn and enhance their connectedness to nature.

The EARPOD project aims at engaging underserved students in experimental education with technologies in environmental education (Hougham, Nutter, & Graham, 2018). These students studied different aspects of leaves, and learned to make scientific observations, one group using classic observation settings, the other using digital microscopes and tablets with micro capture and micro plant apps. After the first session, the students traded places. Researchers found that after the study the students had gained more positive attitudes towards using technology outdoors and had become more interested in nature observation.

In a study of elementary school children in Cyprus, Zacharia et al. aim to provide empirical evidence of whether students' use of phones and tablets for collecting and recording observational data in courses on the lifecycle of plants and their interaction with the environment, improves their conceptual understandings compared to traditional note taking and sketching (Zacharia, Lazaridou, & Avraamidou, 2016). Their findings show that students' conceptual understandings are enhanced to a higher degree when using mobile devices for data collection than when using traditional ways of data collection. More than seen in the control group who used sketch-making magnifying glasses and notetaking, authentic data recording (photos and video) enhanced fourth graders knowledge of "flower, pollinators, fertilization, and the interrelationship between animals and plants" (p. 614). The authors argue that this is an important finding both because it is about 'enhancing conceptual learning,' an area proven hard to understand for students (here they draw on Schussler, (2008) (Ibid.).

An American project, EcoMOBILE, used phones, Augmented Reality (AR) and probeware technology in courses where students studied the water quality in ponds. Teachers reported that they experienced this technology use as very student-centered (Kamarainen et al., 2013) which, as noted by Nayar & Srikirupa (2018) is a common aspect of technology-mediated pedagogies. Teachers experienced that technology, which provides a window into unseen parts of the environment, motivated students in new ways as it helped them identify with scientific practices (Ibid., p. 553):

The teachers indicated that the technology promoted more interaction with the pond environment and with classmates compared to field trips in past years. The teachers stated that they began this project with skepticism about whether the technology would overwhelm the experience, holding the students' attention at the expense of their noticing the real environment. However, teachers and investigators found the opposite to be true. Students were captivated when a squirrel dropped a seed from a tree near the path and nearly hit a classmate; they called out excitedly when they observed a frog near the shore. Meanwhile, the AR offered students a view of bacteria and molecules – parts of the ecosystem that students would not otherwise have been able to witness in the field. Such affordances of AR support student recognition of non-obvious or unseen factors as significant actors in ecosystem dynamics. This addresses a long-standing challenge in helping students to recognize the existence of microscopic and/or non-obvious causes (e.g. Brinkman & Boschhuizen, 1989; Leach, Driver, Scott, & Wood-Robinson, 1992). The tendency to miss non-obvious causes is especially prevalent in student thinking when there is a salient, obvious candidate cause. The affordances of AR enable non-obvious causes to compete with more obvious ones for students' attention (Kamarainen et al., 2013, p. 553).

In other words, augmented reality mediates perception and thereby helps make the unseen seen.

A recently published review of outdoor science learning with technologies focused on forty-five articles that analyzed the alignment of mobile devices – use, intention, purpose for implementing and assessment (Kilty & Burrows, 2020, p. 35). In this, the authors note:

Integration of mobile devices for science knowledge gain represents a missed opportunity to fully leverage affordances of mobile devices. In many studies with science knowledge intent, researchers integrated mobile devices as an electronic textbook or guidebook to look up information, aid identification of species, and provide vague additional resources (Chang, Chen, & Hsu, 2011; Huang et al., 2010; Liu, Tan, & Chu, 2009). Other apps included lesson-tailored worksheets and course-specific information (Hung et al., 2012). These studies integrated mobile devices as substitution technology for analog tools such as guidebooks or worksheets rather than transformative technology in which mobile devices bring affordances not previously available such as adaptive learning tools (Cheung & Hew, 2009; Romrell et al., 2014). Simple substitution of digital for analog tools may not be the most effective use of mobile devices for outdoor science learning (Kilty & Burrows, 2020, pp. 42-43).

In sum, I find this critique of interest with regard to planning new educational courses. However, I also acknowledge teachers' limited preparation time and propose that researchers in this area be more creative and explorative in designing courses. Here technologies and digital platforms could provide opportunities for better technology use within the field of NBS education. The following section focuses on how technologies are used in citizen science projects, which may be seen as adding purpose for users by being part for something larger, as well as helping out nature.

5.3.1 Citizen science and mobile devices in nature

Wallace & Bodzin explore potentials for motivating students toward citizen science by using mobile learning in what they term 'authentic practice' in the project MobiLAP (2017). They found a significant impact on student's attitudes toward citizen science:

The MobiLAP approach builds on the work of Gaydos and Squire (2012) by integrating mobile learning with authentic citizen science experiences to foster scientific citizenship in participants. Mobile phone technologies can create opportunities for amateur scientists to record, share and interpret a wide variety of data for citizen science projects (Kridelbaugh, 2016). Participants that use personal mobile devices may continue to learn informally (Khaddage, Müller, & Flintoff, 2016) and take part in scientific citizenship during non-school hours (Wallace & Bodzin, 2017, p. 50).

Zydney & Schaen report from another successful citizen science project called ‘Noah: Global Schoolyard Bioblitz’, where first and fourth graders worked together to explore the wildlife of their schoolyard (Zydney & Schaen, 2018). They shared photos and wildlife observations on a project web page, and used an app for taking photos and capturing observation data⁶. The authors note that one benefit of this type of outdoor learning is that not much preparation is needed, and that the students are quite resourceful when it comes to finding animals (Zydney & Schaen, 2018, p. 40).

Geocaching in education

Geocaching is a worldwide game, where players use the GPS in their phones to find hidden caches, which is like a post in orienteering or treasure hunts. Geocaching is played both on recreational basis and in instructional versions (Rose, Gosman, & Shoemaker, 2014)⁷. While the basic concept is overall the same, in the following, focus is on instructional geocaching.

After registering on geocaching.com, participating players download a list of waypoints (coordinates including latitude and longitude) and choose which cache to find. Then the player navigates to a coordination to find the hidden cache which is placed in a site to support learning goals (Rose et al., 2014). Through a registered ID or pseudonym, players link their activities on a webpage in way that allows players to recognize each other. Often the cache is a weatherproofed box containing a quiz or tasks to solve. Players, who find the cache, hide it again before leaving the site. Everyone can create new caches so teachers can either use existing caches or make their own.

Clough has been studying learning informal processes in Geocaching (Clough, 2010, 2017). Elaborating on the learning processes she is preoccupied with, she notes:

Participation in the cooperative, social construction of knowledge was not limited to those who were motivated to join the community by technology. Geocachers who wanted to discover new locations were presented with learning opportunities through their interactions with other members of the community and with location. These learning opportunities arose from reading cache descriptions and narratives, and from experiencing locations in a way that was informed by the knowledge and experiences of others through the descriptions and cache logs (Clough, 2017, p. 122).

Geocaching is also used to teach primary students about maps, compasses, latitude, longitude and their use in navigation (Bragg, 2014). Bragg concludes that “geocaching is an authentic, innovative and imaginative way to develop mathematical understandings” (Ibid., p. 14).

In a Turkish study, researchers explore how geocaching can support Problem Based Learning (PBL) in a course for future school teachers on the subject of ‘Atmospheric disasters’ (Adanali & Alim, 2017). In their evaluation they state:

⁶ They note that they since have discontinued the app – and are now working directly on tablets and websites.

⁷ They refer to Mayben, 2010.

Students found IGG [Instructional Geocaching Game] teaching strategy, suitable for the course content and PBL approach. The researcher put various information, quizzes and PBL duties into boxes for Geocaching game. Students said that they reinforced in an enjoyable way what they learned through these box contents. And IGG relieved tiredness of PBL process. Moreover, through boxes and game, [students gained] knowledge, skills and values of the course (...). [...] When relevant literature is considered, it is seen that Geocaching and GPS-based teaching implementations are also able to be integrated to different disciplines, including geographical courses at first, and these increased students' eagerness to learn. The content of Geocaching boxes can be designed in a multidisciplinary manner: activities, duties and hints for the course contents of fields such as Science, Mathematics, Social Sciences, Agriculture, Environmental Problem etc., can be put into boxes. In this study, [the] theme of the boxes is atmosphere-origin natural disasters (Adanali & Alim, 2017, p. 284).

In another project called GeoMobile, students examined a coal-fired heat plant through geocaching. Rose et al. (2014) describe the course tasks here:

After completing a pretest that assessed knowledge of energy systems, each student installed two free apps on his/her smartphone, including a GPS app and a QR code reader (i.e., Commander Compass Lite and Red Laser, respectively). After a brief practice to assure that students could operate these apps, students were organized into small groups of two or three. Each group was given a waypoint and a clue to help locate the first site. Students keyed the waypoint coordinates into their GPS app and navigated to the location. Upon arrival, students did not discover the "cache" as a physical container, but rather located the QR code posted nearby and scanned it using their QR code reader. The QR code reader launched a web browser and navigated to an instructional web page. The web page provided the name of the technical system they stood adjacent to, a set of essential questions to spark curiosity, and hyperlinks to relevant multimedia resources. After investigation of the energy system using the essential questions and multimedia resources as a guide, students individually completed an online quiz (Rose et al., 2014, p. 20).

This shows how geocaching can be combined with other media resources. Brown et al. whose focus is on 'Education in the wild', report from a project called MOBIlearn (Brown et al., 2010), with focus on informal learning through playing location based mobile learning. They are preoccupied with how mobile technology affords location-based learning, understood as both learning in the environment and learning about the environment. They have developed a Context Awareness Subsystem, which allows users to recommend context-based content to other users, eg. historical facts about a place, plant recognition or facts about animals in the nearby surroundings.

5.3.2 Earthcaches

Within the field of instructional geocaching, a particular cache called Earthcache focuses on learning about geology and geodiversity. This has relevance for REGREEN, as it could be used as a gateway for educating children about how water behaves under various circumstances, and for logging NBS -and problems and much more.

Here Clough describes the basics:

EarthCaches are a particular type of virtual Geocache in which some form of inquiry is necessary in order to be able to log the cache, and where the focus is on creating a learning experience. An earthcache has no physical container – instead the GPS coordinates lead to a location where the Geocacher has to conduct an inquiry, guided by the instructions in the Geocache description on the website. The Geocacher, having completed the inquiry, then emails the answer to the cache creator via the Geocaching website, logging the find once the cache creator confirms that the inquiry has been conducted correctly. For example, one EarthCache in the USA asks cachers to take the temperature of a stream at the bottom of a hill, then hike to the source of the stream partway up the hill (using the GPS as a guide), take the temperature there and then, by observing the surroundings and conducting inquiries, suggest reasons for the difference in temperature between the higher and lower areas of the stream (Clough, 2017, pp. 106-107).

I find this inspiring, and thus end this section with Zecha & Regelous's list of five positive aspects of Earthcaching:

- A. Creating an EarthCache and downloading them from the internet is free. In contrast, traditional info boards are expensive in the production and in the maintenance.
- B. EarthCaches are quite flexible. In order to update them, one just has to change the information in the EarthCache description and upload the new version, e.g., to add a new figure. Visitors can go at any time to look for Earthcaches and do not need to book a guide in order to gain specific information.
- C. EarthCaches have to pass a review process before being uploaded and therefore reach certain standards, which makes them different to normal geocaches.
- D. EarthCaches initiate non-formal learning processes in different ways. Visitors have to answer the tasks, in order to log the EarthCache. In doing this, they are actively involved and not just passively listening or reading. There are three stages of EarthCaching learning levels, which may be used for learning geodiversity in National Geoparks (Zecha and Hilger, 2015; Zecha & Regelous, 2018, p. 643).

This ends the brief review. In the following I touch upon research on technology use in Danish outdoor education carried out by a colleague and myself.

5.4 Part 2: The Natural Technology project

In most of the international studies cited in this chapter, technology is used in highly structured settings. In contrast, several of the Danish frontrunners we have interviewed for the Natural Technology project⁸ report that their teaching practices center on a more self-driven, explorative use

⁸ In this project, we have conducted small field studies all over Denmark as well as 25 mini 5-question interviews, followed up with 22 semi-structured interviews of adult users of technology in nature with children and youth (Aull Davies, 2008; Hammersley, 2017; Hammersley & Atkinson, 2007). The interviews lasted for 0,5 – 1,5 hour and were held in virtual meeting rooms, recorded and transcribed (Schilhab et al., 2020 In Danish).

of technology. This can be related to a Nordic tradition of democratic ‘bildung’ in environmental education and education for sustainable development (Læssøe, 2010). While many of the previously-mentioned studies were conducted in collaboration with researchers, the Danish teachers, instructors and nature guides I have been in contact with have themselves chosen to try out different kinds of technology in outdoor settings.

In the following, I present an example of the ‘learning to see’ argument several of our informants touch upon in interviews. A male teacher describes how he uses a Danish app called ‘Naturtjek⁹’ with 3rd – 4th graders to teach them to ‘see’ their surroundings. About fieldtrips, when children are out walking, he relates:

If we notice an animal [we examine] ‘What kind of animal is this?’ It isn’t every animal you can identify through the app, but you might. So if we notice a blue butterfly, ‘well okay, it is not rare’ and so on. It is in situations like this I think it [the app] works well. [...] So I have talked with them about what they have spotted and what we have come across like: What have we seen, where does it live, why is it here and what happens in a while when the winter begins? Yes... -we have a lot of good talks emerging from these trips (Gorm, teacher, January 2019).

The teacher notes four didactic arguments for these rather unstructured activities are: 1) to support students’ verbal development; 2) to enhance students’ use of phones and tablets; 3) to document and support memory of outdoor school teaching activities; and 4) to underpin student curiosity and communicate their findings.

The learning to ‘see’ argument is in line with the Norwegian anthropologist, Harald Broch’s understanding of nature as something we can learn to ‘read’ (Broch, 2005). He explores how members of different cultural groups who utilize nature and natural resources in different ways, have different experiences and perceptions of nature. He states:

Nature is a kind of book that can be read. It is open for interpretation and it is interesting because that ‘book’ will always provide new, unread pages. Every day is different from the one before. Experience directs one’s reading and interpretation of nature, and new information is always being added to previous knowledge (Broch, 2005, p. 139).

Whereas Broch is talking here about the ‘nature reads’ of whalers and sealers in the North Atlantic, I see aspects of this learning process in activities designed to provide students with environmental literacy. First of all, students need to learn to see the nature around them, to actually see beetles and butterflies and acquire knowledge about them and their role in nature’s cycle – from the students’ cultural groups’ perspective.

Martin, another teacher of 6-year-olds, wants to teach the students to use phones for knowledge finding. He explains his use of technology in nature as follows:

It can be anytime on a fieldtrip where we’re walking from A to B and come across a plant or an animal we think looks interesting. Or it can be something someone spots. To me it is important to underline that it is important to use our senses to ‘what can I smell?’, ‘what can I hear?’, ‘what can I see?’. Then when we spot something we want to know more about, I suggest: ‘Should we try and look up what this can be?’ Because it is easy merely to

⁹ It is a national Danish Citizens science app to identify and register flora and fauna.

improvise and tell them what it is... [...] But I think there should be room for us to investigate and explore together. So it can be a characteristic Heteroptera [tæge], a Pentatomoidea [bredtæge] for example. "This is one of the Pentatomoidea," I could say, you know, "and we have a lot of types of Pentatomoidea in Denmark, right. They are part of the Hemiptera [næbmundede]" insects". Then I say "Why don't we write Pentatomoidea [In a web search engine] and then see which pictures show up, and then study what fits with this one we found, who have a bit of wide sharp shoulders and a yellow spot here and stripes there...". Then it varies a bit but often we'll end up agreeing that it must be this one, right. Then we take some good photos and they will become part of the news when we get home. I will document such a fieldtrip from when we leave the kindergarten so it will be a story in pictures with text (Martin, nature pedagogue, December, 2019).

This teacher works together with his students to sustain their curiosity by teaching them how to find knowledge through the phone. A third teacher, Katja, find it useful to use phones in outdoor school to provide physical and embodied knowledge, which can be used for learning about abstract concepts. Katja, a teacher of 1st – 6th grades explains why she uses technology outdoors with her students:

I experience that my students – when they get outside the classroom – they acquire... well first of all their motivation rises. Also their inner skeletonizing regarding attaching knowledge to an experience - It is easier when we have been outside trying something [...] Well I can hear that the children are using them [the fieldtrips] as stories. For example, once we had stories attached to fieldtrips. We had been to the forest. We had been studying biodiversity in two different types of forests, and made such a phone-based picture book of the two different kinds of forests, right. And it was clear that they talked a lot about the books they made, instead of the word biodiversity (laugh). It was only when we connected biodiversity with the books... And now they've got something... an experience of attaching the term in order to make sense of it, you know (Katja, It-counselor, consultant, teacher, September 2018, s. 5)

Here the fieldtrip together with the virtual books in which they documented and registered information about two different forest types become the first mental 'hook' into the more abstract term, biodiversity.

A fourth aspect I hear more Danish educators explicating is a wish to teach students to use their phones for other things than texting, calling and being on social media:

It is mostly due to if we can get there, where we can show what normally not is visible. If technology can provide that extra dimension. Possibly through so massive an enlargement or through making a literacy possible. Then it makes sense. But if it does not make sense, then keep the technology away (Kristian, Nature guide and biologist, December 2018)

While Kristian's argument of using technology only when relevant makes good sense, technology does have the potential for making the unseen seen and the unheard heard.

I have presented these four voices from Danish outdoor education with smartphones to provide readers with another kind of knowledge than the structured courses described in international literature. The international studies predominantly report on researcher-structured training courses whereas the Danish project Natural Technology reports from teacher-initiated experiences and with a broader focus on what technology does to children and youth's nature experiences. That Danish teachers participating in the study seldom refer to researcher-structured training courses illustrates

that they may to a higher degree be driven by personal motivation and didactic curiosity with regard to using technology outdoors.

5.5 Examples of potentially relevant apps for working with children and nature

I end this chapter with a list of examples of apps, which can be used nature based learning. This is not a list of recommended apps, but merely an example of which apps exist.

Encyclopedia apps	Environmental apps	Apps for creative technology use	Citizen science apps
Picture This	UN Climate Change COP 25	Video	iNaturalist
Plant snap	Climate Change Frontier	Camera	eBird
Seek	Climate Change Awareness	HP Reveal	Earth Challenge 2020
Schroomi	Environment Challenge	Explain Everything	Tool apps
Mobile Observatory	CarbonBuddy - Your friend to tackle climate change	Stop animator	Vibrometer: Seismograf
Planetarium	Climate change is real	Dictaphone	Smart Protractor
Leafsnap	Earth Hero: Climate Change	Book Creator	Magnifier & Microscope
Heavens above	PhenoloGIT	iMovie	Sound Meter
Sky view	Water Cycle HD		Lux Meter
	Sustainability News		Compass Galaxy

UK teaching material about flooding <https://microbit.org/en/2018-02-13-iet-lessons-4/> & <https://tv.theiet.org/?videoid=10078> – the last is about engineers work on that

<https://tv.theiet.org/?videoid=7297>

Especially recommended literature on this topic

(Schaal et al., 2018; Shaal & Lude, 2015; Zimmerman et al., 2019)

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6. PLAY BIOTOPES - THE MAPPING AND CO-CREATION OF URBAN NATURE WITH AND FOR CHILDREN IN A LANDSCAPE LABORATORY IN SWEDEN

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6.1 Introduction

Engaging children in natural settings, where they may experience biodiversity, has been associated with children's wellbeing (Hervey et al. 2020) but the possibility for children to engage in such settings varies a lot across neighborhoods and regions (Freeman et al. 2017). This paper focuses on the possibility of developing land rich in its morphology, flora and fauna - which can support children's connection to nature during play and learning.

Our point of departure is a recently initiated co-creative process on urban nature, with and for children at the landscape laboratory of the Swedish University of Agricultural Science (SLU) in Alnarp, southern Sweden. The Alnarp landscape laboratory, covering approximately 20 hectares of land and including a variety of forest stands, forest edges, meadows, wetlands and water bodies, is used for experimental landscape design, construction and maintenance.

Research in environmental psychology reveals that contact with nature benefits children's cognition, with overall effects on executive functions such as attention and self-discipline (Wells et al. 2018). In much of this research, methods for assessing the quality of the natural physical environment are rather crude. One early project described nature as a present or non-present variable, more or less rich or uniform in character (Grahn et al. 1997). Today researchers commonly make up lists of "affordances" for documenting the play value of an outdoor environment (Heft 1988), drawing on the theory of direct perceptions developed by James J. Gibson (1977). When applied to play spaces, this suggests that attributes like open ground, sloping terrain, sheltered places, rigid fixtures, moving fixtures, loose objects, loose material, water, creatures and fire, present particular affordances that offer children opportunities for meaningful action, with each feature facilitating particular activities, such as climbing, sliding, jumping etc (Lerstrup and Konijnendijk 2017). The affordance perspective with its focus the "doings" of children helps to highlight the play-value of particular physical attributes in a natural setting, but has its limits when it comes to investigating overall use and interconnectedness between children and place as they move about and experience a natural environment. We suggest that developing play spaces with a more complex landscape composition and biodiverse flora and fauna need new concepts to describe the child and landscape interface. With landscape ecology as a backdrop, Ingunn Fjørtoft (2012) has introduced the concept of "play biotope" into the vocabulary of children's outdoor play environments.

Academic interest in the more complex interrelationships between children and outdoor places has paralleled efforts to develop tools for handily mapping the quality of children's outdoor play environments. Qualitative investigations have been uncovering how the content and configuration of physical environments contribute to children's play and mobility in everyday life (Johansson et al. 2020) with extensive documentation from Great Britain, Italy and Scandinavian countries, including

some low-income countries as part of the UNESCO- initiative “Growing up in cities” (Chawla 2003). We know from these and other studies that natural elements contribute to the general attractiveness of neighbourhoods for children (as well as adults) by providing affordances to play, supporting emotional bonds with place and making available places for both vista and refuge (Johansson et al. 2020). We know little, however, of how landscapes of particular regions may contribute to children’s play and learning and their overall way of being in their world, through particularities of topography, vegetation, flora and fauna, e t c. To highlight the specific role and potential of natural environments, we need to be able to conceptualize what high quality urban nature for children might imply. In preparing to explore the distinct play values of a particular piece of land in the Alnarp landscape lab at SLU, we are searching for a terminology to describe this interface between children and place. In collaboration with the planning practices of landscape architecture, we draw on the bulk research on children’s outdoor environments in environmental psychology and ecology. We hope this will be a contribution to the creation of urban nature as part of livable cities, which are sustainable and help to produce eco-system services.

The vocabulary of ecology might enhance the study of how play activity depends on and evolves in relation to various environmental cues. To systematically investigate and develop nature-assisted play and learning, we suggest paying attention to the overall composition of specific landscapes and the particular affordances they comprise. A play biotope describes how characteristics of topography and vegetation compose complex “habitats” that engage children in particular activities (Fjørtoft (2012). In a similar vein, a set of Outdoor Play Environment Categories (OPEC), were developed to describe the composition and content of health-promoting outdoor environments at preschools (Mårtensson 2013). A succession of studies have been showing how preschool children with access to high OPEC environments, which are spacious, green and a contain a good mixture of more closed and open surfaces, engage in health-promoting play behavior with direct effects on their sleep patterns, attentiveness, fitness and overall wellbeing (see Boldemann et al. 2015 for a summary of the studies).

Most studies of children’s outdoor environments take departure in pre-existing facilities for outdoor play, in parks, schools and pre-schools, where much of children’s everyday life take place. The remains of natural elements in such programmed play-space, such as sticks, leaves and stones, relentlessly turn into treasures, as loose material if nothing else. These studies, however, tell us little about the actual potential of creating sites for nature-assisted play and learning in urban settings. Our question is how to offer children living in cities more opportunities to engage with biotopes of more vitality, variation and abundance and what it might contribute to children’s play and learning if we do so. In preparation for the co-creation of enriched play spaces together with children, our first step is to find ways to frame and describe the play value of biodiverse landscapes in terms compatible with children’s use and perspective.

6.2 The lab

The landscape cannot be moved to a laboratory, therefore laboratory thinking needs to be moved to the landscape (Nielsen 2011). Led by this thinking, the Swedish University of Agriculture Sciences has established landscape laboratories (Gustavsson 2002). Different approaches to creating biotope rich, multifunctional landscape are tested and demonstrated on a scale of one to one to aid transdisciplinary research, demonstration and teaching (Gustavsson 2002). The first landscape

laboratory was started in the 1980s at Alnarp Campus and has since been followed by Landscape laboratories in Snogeholm Sweden, Holstebro, Denmark, and recently also in Aarhus and Copenhagen, Denmark. Today the Alnarp landscape laboratory is not only an arena for research, demonstration and teaching, it is also a popular recreational area for local residents, not least for different children's groups. One particular area called Alnarp's Västernskog, established in 1994, provides the opportunity to study the use and co-creation of play-biotopes. Covering 14 hectares, with 37 different woodland stands, a wide variety of edges, meadows and water environments, it provides a rich canvas of different environments to study and re-create using co-creation approaches involving children as well as university students.

6.3 Mapping biodiversity

Long-term systematic mapping of urban green areas is almost non-existent. In general terms this means that there is little knowledge of the quantity of nature (cover of land habitats) and quality (species of plants and animals) in cities. This, in turn leads to meager knowledge of any changes in the quantity and quality of urban green areas in general and for children in specific. Detailed species mapping often occurs prior to exploring an area for infrastructure, to evaluate whether there are any rare or protected species that could hinder development. More recently, rapid progress has been made in remote sensing techniques with high resolution satellite images and aerial photos, making it possible to show present state (or a decade or so back in time) through high-resolution satellite images or infrared photos of urban green cover. Remote sensing techniques, however, have some major limitations. First, they can date back only as far as existing satellite images of aerial photos allow, and this varies between cities and within areas in cities. Second, the resolution of so-called LiDAR, using laser data, may vary within cities (Hedblom et al. 2017), and thus only coarse estimations of e.g. "forest cover" can be made, and not "age of forest" or whether "deciduous forest" or "coniferous forest." Third, remote sensing techniques cannot reveal changes in shrubs that are covered by trees or, in any convincing way, map larger urban covers of small and very scattered green, such as lawn (also under trees; Hedblom et al. 2017). Finally, and specifically, remote-sensing techniques cannot reveal anything of on-the-ground quality, such as animal and plant species or biodiversity in general.

Few existing studies include a systematic inventory of the habitat cover, species and biodiversity of children's playgrounds over time. Most inventories include synchronic overviews of an area. But because methods vary greatly, and are not systematically deployed, it is not possible to repeat over time or compare with other study areas. Sometimes, children themselves are involved in the inventory such as Vigie Nature, <http://www.vigienature.fr/fr>). Taken together, these practices make it difficult to compare prerequisites for children's contact with nature across locations, since "nature" is not defined and biodiversity not quantified. Using specific monitoring schemes to quantify specific playgrounds would allow for more straightforward estimates of cognitive qualities or socio-economic prerequisites; a baseline for nature (biodiversity) makes it possible to include or exclude nature (biodiversity or habitat cover) as a confounding factor in children's behavior.

Global studies (based on field sampling) shows that biodiversity in cities is still rather high but rapidly decreasing (Aronson et al. 2014). A systematic approach would allow us to evaluate whether the habitat and biodiversity of children's areas are decreasing or increasing over time. At present we know that decreases in the amount of urban green areas will reduce biodiversity (Seto et al. 2012), but this

knowledge is very general, as there are only a few systematic studies on the biodiversity of cities (but see Aronsson et al. 2014, one of the few global studies). Hedblom et al. (2017) suggest that a decrease in urban green areas “forces” people to find recreation in peri-urban areas. However, this applies mostly to adults, as children and the elderly tend to use nature or green spaces in the vicinity of their homes, making the quantity as well as quality of these green areas/nature of great importance.

Large-scale monitoring of biodiversity is both costly and difficult due to high labor costs for fieldworkers and a need for people with special knowledge of flora and fauna. Because of this, many monitoring programs make use of more cost efficient remote sensing techniques rather than fieldworkers. Due to this, as noted, knowledge of changes in urban biodiversity over time is almost non-existing (except in specific areas). However, since the areas children use are rather limited, it might be possible to find a method for mapping/monitoring the biodiversity of children’s play-biotopes that is both cost efficient, and easy to monitor without detailed knowledge of species.



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Figure 1: Illustrating how a biodiversity inventory could be conducted in a play-biotope. The yellow circles have different sizes and each size has a specific detailed level of inventory. The circle on the lower left is where the total cover of different habitats is mapped.

6.4 Mapping procedures revisited for the development of play biotopes

The general interest of safeguarding children play spaces of high quality has been accelerating in recent years and with this, efforts to develop tools and checklists to map, assess and evaluate

children's outdoor environments. The Outdoor Play Environment Categories (OPEC) mentioned above are intimately linked to the need of operationalizing the physical environment into a researchable variable, while other tools have been developed for practitioners who are about to take decisions related to play facilities, for example a municipality who wants to get a basis for prioritizing. Woolley and Lowe (2013) emphasize the importance of environments being "enticing", "stimulating", "challenging" and "inclusive", while Lerstrup and van den Bosch (2017) emphasize "uniqueness", "size", "gradation", "novelty", "change" and "abundance". Also Jansson and Andersson (2018) list characteristics of the physical environment, which touch on factors related to the overall design and the actual use and function of a particular place over time. They talk about the importance of: 1) varied topography, playable vegetation and loose material, 2) integration of elements, accessibility and social life, 3) environment understanding, and 4) character in terms of spaciousness, variation and enclosure.

Attention to the quality of children's play behavior is vital in the development of play biotopes for children. Helen Woolley and Alison Lowe (2013) have been developing an encompassing strategy for evaluating play spaces as part of strategic work for improvements which include the assessment of environmental characteristics relevant for particular types of play behavior, for example exploration, imaginative play, and games, e t c. The fact that exploration is a vital dimension of children's play outdoors needs special attention. The flexibility of play sequences, more open to exploration and the whims of the individual child, which tend to evolve outdoors can help to explain the health impact acknowledged where children have access to green play settings (Mårtensson et al. 2009). In a similar vein, Cox and Loebach (2020) have been revising the terminology for play behaviors evolving in natural environments to include exploration, and also bio-play, together forming "the play of flux and transformation" typical for green outdoor settings (Mårtensson 2004).

In the development of settings for nature-assisted play and learning, a landscape perspective on children's environments is needed to uncover the intricacies of children's relationships to outdoor places. The OPEC- tool mentioned above focuses on the total size of an outdoor area, the proportion of surfaces with trees, shrubbery, or hilly terrain and integration between vegetation, open areas, and play areas. This seemingly straightforward list of play promoting attributes presupposes natural environments that cater for a substantial amount of the affordances that engage children in play, by prescribing a layout and composition of factors that together facilitate the overall play flow

In this study of co-creation in nature with children in the REGREEN project we concentrate on the particularities of nature supporting children's play and learning. A perspective on children's relationships with nature, enriched by knowledge of ecological content and structures, could possibly open up for new interrogations into the interrelationships between children and landscape. We take a closer look at play space as a biotope – a so call play biotope - with a particular content of flora and fauna and composition of structures related to the morphology of place and its vegetation. Our motive is the apprehension that many studies so far have had a very crude perspective of children's play spaces as landscapes, mirrored in the crude terminology of mapping procedures, with the risk of reproducing poor environments. Efforts to counteract "plant-blindness" in environmental education (Nyberg and Sanders 2014) could possibly be supported by an approach more sensitive to the landscape.

6.5 A tentative idea of an integrated enriched perspective on mapping play spaces

Play spaces are mapped differently in various disciplines as mapping has a different function and objective and subjective site appraisals are differently deployed. In this study we concentrate on mapping procedures in situ; we do not depend on collecting information from users or draw on any advanced techniques.

A tentative way to carry out the mapping could be as follows:

- 1) Decide on a specific geographical area accessible to the children.
- 2) Carry out an inventory of the ecological content offering play and learning props in different samples at different scale levels (50 meter, 20 meter, 10 meter)
- 3) Identity and spell out play biotopes as combinations of elements/species with an ecological value and an associated play value, for example: *Standing dead wood as habitat for wood-living insects and birds offering cues to climb, hide, make arrangements and look* (Appendix 1).
- 4) Mark the distribution of play biotopes on a map of the area and then evaluate these as part of a site's overall layout and composition, to estimate how well the place may accommodate children's more mobile play sequences. The strategy includes assessing the total size of the area, the abundance of trees, bushes and hilly terrain and the degree of variation, for example a mix of enclosures and open spaces.

6.6 Co-design – manage with design

Participatory research processes have been widely encouraged in international conventions such as the Local Agenda 21 Action Plan (UNCED, 1992), the European Landscape Convention (Council of Europe, 2000) and the EU's Aarhus Convention (Stec et al., 2000). Lately, the 2030 Agenda for Sustainable Development focuses on decision-making with particular reference to the participation of vulnerable groups, such as children (SDG targets 5.5, 11.3 and 11.7).

Co-creative processes in green space development build on a shared sense of purpose for the participants, in that they develop areas with local values for the people involved with the material of the green space identified (Neal et al. 2015). For effective participation, methods suitable to the groups involved are necessary, along with tools that fit the different stages of development and management. While there are many studies reporting on participatory processes in planning and maintaining green space development, few studies focus on the use of or co-creative processes in designing green space management (Fors et al. in review). Co-design is a partnership approach engaging different members of the public and designers in a joint drafting, planning and implementation process (Sanders and Stappers, 2008). Co-design allows user-specific values and needs to be incorporated into the design process and subsequent reconfiguration of green space.

Green space managers often lack knowledge of how to involve users which tends to result in ad hoc process (Molin & van den Bosch, 2014; Randrup et al., 2017). Fors et al. (2020) have highlighted the

importance of identifying suitable tools for particular user groups to achieve successful co-creative processes in relation to green space management. Children in particular are often excluded from co-designing green space development and the tools at hand not suitable for involving children. It is also important to consider the huge differences in working with children of different age groups - toddlers, school children, adolescents and youth.

While studies with children in co-design processes are sparse, some examples can be found. Carroll et al. (2017) report on a co-design process with children in relation to the Redevelopment of a Central City Square in Auckland, Aotearoa/New Zealand. Engaging children in planning a redevelopment involved observing them play in the city square, eliciting photographs taken by children and holding workshops with them. In a recent study in Copenhagen, children were involved in co-designing open public space in a deprived neighbourhood (Pawloski et al. 2017). This involvement included mapping, creating collages, and building full-size prototypes in the public green space. Children were also involved in the actual implementation of interventions in the form of urban installations. Different forms of co-design with children have also been carried out in schoolyards (Menconi & Grohman, 2018; Jansson et al. 2018). It is important to acknowledge the great span of relevant formats for involving children in participatory processes. Children can be observed by adults, serve as informants in data-collection similar to traditional research strategies (for example transect tours), get involved in workshops or participate in interventions with hands-on change of place.

The strategy of organizing workshops with children has been tried out in the Alnarp landscape laboratory with schoolchildren helping to clear out the forest, a strategy that has been carried over into projects involving younger preschool-children. During children's visits to the laboratory on excursions with pedagogues, we document and analyze their play sessions, make adjustments to the site by clearing out to create small paths, cutting to make more twigs available e t c. Then groups visit the place again, and we document and make some further adjustments, and so forth. In the next phase, we intend to identify and develop play-biotopes by involving the children and their pedagogues in more active cooperation, to investigate opportunities for playing and learning residing at the site, in its flora, fauna and in particular in the affordances and composition of the landscape.

Nature and vegetation contribute to dynamic sites dependent on different natural processes. Design cannot be separated from management when deploying nature-based approaches. The original design can only set the scene for forthcoming development (Tregay 1983, Konningen 2004, Gustavsson et al 2005; Wiström et al 2020). As such, management becomes design put on a time continuum. A planting of trees and shrubs can, depending on thinning and pruning strategies, develop in radically different ways with regard to structure and species composition (Tregay 1983; Oliver & Larson 1996). Given this wide variety of possibilities for development, a large degree of creativity and design-based thinking is essential also in the management stage (Tregay 1983, Konningen 2004). This type of "design by management" or "creative management" (Tregay 1983, Ruff 1987, Konningen 2004) demands a high level of place specificity and a hands-on approach (Wiström et al 2020). This means that traditional design approaches, and related communication approaches that rely on one main illustrated design that is then implemented and maintained, are becoming less applicable (Tregay 1983; Gustavsson et al 2005). However, co-creation approaches are more suitable since they enable active engagement in both the design ideas and their implementation.

At the Alnarp landscape laboratory, research on creative management approaches has demonstrated their success for nature-like environments created from scratch (Duinker et al 2017; Hladikova & Sestak 2017). In the landscape laboratory at Sletten Holstebro, co-creation with inhabitants has resulted in the formation of a co-management zone in the immediate vicinity of houses (Fors et al 2019). As such creative management and co-creation are applicable both when working with existing nature and when creating and restoring nature-like environments (e.g. woodlands) from scratch. What unifies these different contexts is that they focus action on specific places, on a relatively small part of the total area, leaving the overall matrix for more standardized management approaches and as such activating the landscape with relative small resources (Lerner 2014; Wiström et al 2020).

There has been very little in-depth exploration, in studies or in landscape laboratories, of ways of involving children in such creative and co-creative management. The pioneering studies of Gillis in Delft have however highlighted that successfully designed natural environments for children can lose much of their quality over time if not managed properly (Ruff 1987; Gustavsson 2004). This highlights a need for identifying suitable and transferable processes and methods for involving children in co-design through the creation and management of play biotopes. There is a need to identify and develop processes for how co-design involving children could be part of an active management process for creating site-adaptive play biotopes. This process should also include evaluating the effects of co-design processes on the landscape using adequate mapping tools that combine biodiversity inventories with play biotopes as described in this chapter. This provides a powerful set of tools for working with the creation and management of urban play spaces *with* children and *for* children, play biotopes that draw on the affordances residing in nature and in children's fascination with nature.

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6.8 Appendix 1. General outline of inventories for mapping potential play attributes of natural environment

Element and species	Ecological value	Affordances	Ecosystem service
Number of minor dead branches	Substrate for mushroom and other decaying organisms	Arrange, Modify (Huts) Fascination, Curiosity	Increase the amount of natural enemies of e.g. bark beetles. Regulating service
Number and circumference of larger laying and standing dead wood	As above and also habitat for wood living insects and birds etc.	Climb, Arrange, Jump, Sit by, Kick, Crawl, Hide Look for, Look after (Place creation)	Increase the amount of natural enemies of e.g. bark beetles. Regulating service
Number of large stones (larger than 0.7 meter in diameter) and cairns (size of cairns (stenröse in Swedish).	Habitat for reptiles and insects. Overwatering areas for frogs and salamanders.	Climb, Balance, Sit by Arrange (Place creation)	Regulating service (habitat for species)
Amount of the area covered of minor water creek or minor open water	Habitat for insects, amphibians, water source for various animals, habitat for plants	Pour, Mix, Slash, Float (change way of water) Look for, Look after	Reducing water runoff
Old trees (tree species, circumference, and leaf area cover)	Habitat for lichens, mosses, insects, birds and mammals	Climb, Balance Spin, Sway, Swing (if added material) Arrange	Increased air quality, removal of CO ² , removal of particles, shadow (reduce heat-island effects), ruff off water reduction. Reducing noise.
Multilayered vegetation – ground layer, shrubs and trees (define the layer, count the number of layers, species in the layers).	More plant species, more substrates and habitats for different animals	Frame, Hide as (Spatiality) Arrange, Modify as tools, Props, Treasures	Reducing noise, increased air quality, removal of CO ² , removal of particles, shadow (reduce heat-island effects), ruff off water reduction, reducing wind (also for parents watching their children)

Shrubs and trees with berries (number and species)	Food for insects, birds, mammals etc	Arrange, Modify as tools, Props and Treasures (Sensory experience fragrance, taste, form, aesthetics).	Food
Dry and sandy environments (area)	Habitat for specific insects, flora and fauna	Props, Treasures Dig, Move, Mould, Smear Fantasy	Regulating service (habitat for species)
Marshes and wetlands	Habitat for specific insects, flora and fauna	Look for, handle, care	Reduction of runoff water
Varied topography	Larger number of niches (more humid, drier, etc.)	Roll, Slide, Clamber, Hide	Noise and wind reduction??
Bird (count numbers of individuals seen or heard).	High number of species indicates high ecological value	Fantasy, color, sensory experience of sound	Bird song increase well-being, birds provide services such as removal of insects damaging foliage
Herbaceous plants	High number of species indicates high ecological value	Fantasy, color, sensory experience of smell	Smell increase well-being
Diversity of habitat (area and number of habitats)	Higher number of habitats provides prerequisites for more species.	Diversity in play.	Increasing the resilience.

7. ACTION-ORIENTED ENVIRONMENTAL EDUCATION, CITIZEN SCIENCE, AND NBS

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7.1 Introduction

This chapter introduces, and draws on, action-oriented approaches in research on environmental and sustainability education.¹⁰ Their relevance for Nature Based Solutions (NBS) lies in regarding schoolchildren not just as science learners or potential producers of data for NBS science and planning, but also as citizens, agents (and learners) in NBS governance processes.¹¹ Schools may enable children's participation in civic learning processes by collaborating with communities and municipalities on actual NBS cases and by integrating science and citizenship education, for example through elaborating on versions of citizen science education or applying other kinds of participatory and case-based methodologies. This approach does not however translate into practice without running into roadblocks. Thus, in unfolding this perspective, this chapter also addresses challenges and what might be done to cope with them.

In times of accelerating climate change and biodiversity loss on a global scale, the field of Environmental and Sustainability Education (ESE) is gaining increasing awareness among both educators and educational researchers. As research fields, environmental education (EE) and ESE are however not very new. Since the United Nations' first conference on EE in Tbilisi in 1978, research literature on EE has steadily grown, and since the early 1990's has included ESE and 'Education for Sustainable Development (ESD)'. On the database 'Academia.com', ESD gives more than 125.000 hits. This reflects a growing interest in the field of sustainable development, as well as the fact that education is a huge field, covering many types of education and pedagogical theories.

To help position this research field, we can look to Wals, Brody, Dillon and Stevenson to distinguish EE from early science education (SE):

An example of the difference between early SE and EE is that, while the former might teach students how to monitor water quality, identify pollutants, and understand technologies that can reduce pollution, EE would involve an analysis of circumstances and behaviors that caused the pollution, as well as identifying ways to clean up a river involving the local community, policy-makers, and industry (Wals, Brody, Dillon, & Stevenson, 2014 p. 583)

This distinction should not be regarded too sharply, as there is obvious overlap. As the following quote expresses, science education supports citizenship education.

Scientifically literate citizens may have the ability to assess the value of knowledge in a particular context and to participate in the social negotiations that produce knowledge (Roth and Désautels 2004). They may also be capable of critically evaluating the scientific evidence

¹⁰ Action-oriented approaches refers to pedagogies emphasizing what the educational philosopher, John Dewey, termed 'learning-by-doing' (Dewey, 1938). Through action, learners influence their surroundings and perceived responses that may contest or add to previous sensuous-emotional and cognitive orientations and thus give rise to experiential learning. Cf. expanded explanation later in this chapter.

¹¹ Action-oriented experiential learning is basically the way all humans learn throughout their lives. However, this approach is most often employed in citizenship education to involve children as agents in environmental and sustainability issues at secondary or higher levels of schooling.

touted by politicians, corporations, or environmental organisations, and other interest groups (Schusler & Krasny, 2008)

On the other hand, EE may provide learners with meaning and perspectives that enhances their motivation for SE by relating to their life worlds and social contexts, as well as to environmental controversies, ethical dilemmas and political choices.

Today, many scholars prefer to replace EE with ESE. Including a sustainability perspective emphasizes the importance of widening the scope from ‘what is good for us, here, and now’ to ‘what are the consequences of our actions for others, at other places, and for future generations’ (Heinberg, 2003). It also emphasizes the systemic and wicked character of environmental issues at a time when we are facing unsustainable developments that must be addressed before it is too late (K. Van Poeck, Goeminne, & Vandenabeele, 2016). From an educational perspective, this involves the challenge of scaffolding the development of learners’ cognitive, socio-emotional and behavioral capacities to cope with sustainability issues and participate in creating sustainable futures (UNESCO, 2017).

One of the key pedagogical controversies in EE/ESE/ESD research has been between instrumental-behavioral instructional approaches versus open-ended participatory empowerment approaches. (Jensen & Schnack, 1997; Jickling, 1992; Vare & Scott, 2007). Educating in NBS can easily become just a matter of instructing learners to ‘do the right things’, i.e. to contribute to the implementation of solutions made by science-expert and public planners. However, in that NBS has an incipient ambition of combining green technical with social and health perspectives, it relates well with an ESE pedagogy that regards people (including children!) as participants whose learning is an open-ended and integrated part of processes of socio-material change.

Drawing on this open-ended, action-oriented pedagogical approach, the next section expands on different ways of thinking about participatory and action-oriented ESE, including the challenges and possibilities that may arise in applying these in schools and non-formal educational venues for children and youth. Following a general introduction, the subsequent discussion draws links between citizen science approaches and participatory, action-oriented ESE with reference to academic research that has theoretically and empirically explored the merits and challenges of combining these approaches. Finally, the last part of the chapter discusses other potential ways of applying participatory, action-oriented pedagogies as part of NBS processes.

7.2 Action-oriented ESE pedagogies

There is a widespread assumption that we learn by being presented with information – viewed as an intellectual resource that guides practice. However, even since ancient times, learning theorists have stressed that learning basically starts with sensing, doing and thus experiencing social-material responses (Lippe, 1979). As the educational philosopher John Dewey put it, we learn by doing. By far the largest part of what we learn is non-conscious, but sensory and emotionally embedded knowledge can become partly conscious and intellectually reflected into experiences, which we draw on when meeting new challenges and deciding how to act (Dewey, 1938). The notion of action used in action-oriented approaches does not refer to every kind of human behavior but specifically to intended, experience-based interventions (Schnack, 2003). The action-oriented concept of learning makes sense in relation to both individual and collective social learning. In the field of action research and action learning, social learning is described as a spiraling process whereby actions give rise to sensuous-

emotional impressions that are collectively elaborated into experiences on which plans for new actions are created (Lewin, 1946).

Action can be included in pedagogical designs in different ways. Hammond distinguishes between learning *about* action, learning *through* action, and learning *from* action (Hammond, 1997). Learning *about* action does not entail any direct relation to actual action projects. It typically involves teaching students the skills of taking action, the history of action projects and providing them with examples of action projects as models. Students may for example study NBS cases or study principles of NBS management and apply them to simulations, role-play, mock hearings, etc. (McClaren & Hammond, 2005).

Learning *through* action entails learners getting directly involved in actual projects. Learning of this kind occurs in daily practice as well as in non-formal educational settings such as social movement groups. In formal educational settings, learning through action involves students in 'real world' projects with tangible outcomes other than reports, presentations, proposed solutions or decision-making. Hammond makes a distinction between three levels of action projects. At *Level 1* students engage in the design, development and implementation of action projects that produce products or have tangible outcomes (ibid). In relation to NBS, this could be building a nature trail, planting butterfly gardens or installing nesting boxes for birds. *Level 2* is characterized by designing and implementing ongoing, long-term projects. Related to NBS, students might, for example, permanently maintain a wildlife management area or gradually transform the school into an Eco-school. At *Level 3*, action projects are characterized by designing and implementing changes in policies, regulations or laws. In relation to NBS, this could be school involvement in governance processes, partnerships and co-learning networks on enabling and promoting NBS projects.

Learning *from* action refers to an extension of the two previous types. It comes into play when students review projects or cases presented in learning *about* action programs, or their own direct experiences in community projects. As a debriefing process, it affords time and space for evaluating outcomes and processes and reflecting on what can be learned for future projects (ibid). In relation to NBS, schools may help develop students' action competence and even contribute to social learning surrounding NBS in the local community and municipality.

Learning designed to take place *through* and *from* action implies some form of *participation*. *Participation* is a key concept in relation to democracy, governance, innovation, community development, social welfare and coherence, and a key concept in learning theory and pedagogy as well. While the concept is the same, there are slight differences in the way it is used in the above-mentioned fields due to their different aims and interests. From an educational perspective, and more specifically from an environmental learning perspective, Læssøe and Krasny have identified four different conceptions of participation and learning (Læssøe & Krasny, 2013).

1. *Participation as encounters with Nature*: Here participation is a physical and at times emotional encounter with nature. Theoretically, it refers to learning theories that stress the importance of sensing, influencing, and experiential meaning-making. Pedagogically, it points to the importance to moving beyond the classroom and school to be and act on site. Related to NBS it could for example involve nature observation, tree planting events or social encounters such as interviewing residents in the area.
2. *Participation as socially situated learning*: Rather than focusing on the nonhuman elements of natural environments, this approach foregrounds socially-situated participation in communities of practice, where novices learn from those with more experience. In relation to NBS, internships that allow students to participate in resource management tasks or school

garden projects, where students have the opportunity to meet and be guided by professional gardeners, cooks and permaculture practitioners, may both exemplify this approach.

3. *Participation as collective action*: This approach is distinguished by its focus on participating in collective social action to solve real-life social and environmental problems. In this, learners are conceived as agents and participation as a process of gaining experience and competence as citizens in a democracy (Fien, 2000; Jensen & Schnack, 1997). Pedagogically, this may be set up as an IVAC-process,¹² starting with learners jointly identifying and investigating a problem, envisioning potential solutions and developing proposal for action and then acting to make a change (Jensen, 2004). This approach has been used world-wide, for example in UNESCO's 'Sandwatch' projects, where students study a beach area, imagine and develop suggestions for how they would like it to be in the future, and make an exhibition and/or call a meeting with local residents to start a democratic dialogue on solutions (UNESCO, 2010). In relation to NBS, this is obvious a way of involving secondary school children and youth as both democratic citizens and learners.
4. *Participation as deliberative dialogue*: Similar to participation as collective action, participation as deliberative dialogue is focused on supporting learners in their role as citizens. However, here the emphasis is on a political process of dialogue with other citizens and stakeholders. While relations to physical sites of nature are more detached, dialogues with other people become a strong source of learning as the learners are confronted with discourses and values that challenge their own ways of thinking and valuing (Öhman, 2008). Related to NBS, this points to school and learner involvement in governance processes.

These four types of participation do not exclude each other. In school-community collaboration on NBS projects, they are all potentially integrated. These forms of participation are however easier to suggest than to actually carry out. Participatory action-oriented environmental and sustainability education is not just a simple technique but a very demanding alternative pedagogical approach, when compared to conventional teacher-led, curriculum-fixed, classroom teaching. This also means that there are several obstacles to overcome.

One obstacle has to do with the existing educational structures at all educational levels. In most countries, the majority of educational institutions use single-subject curricula, which makes interdisciplinary projects difficult. More or less fixed curricula for each subject area reduces opportunities for innovative action-oriented projects into add-on's, that take place during inter-subject thematic weeks once a year. In addition to curricula, descriptions of intended learning outcomes and ways of examining and evaluating students typically constrain the view of learning to matters of factual knowledge and instrumental qualifications. This is at variance with action-oriented pedagogies that focus on complex real-world issues. With no right solutions, learning objectives include holistic and generic 'bildung' with regard to gaining competencies of import for navigating, collaborating, critically assessing and enacting individual and collective interventions. (Læssøe, Schnack, Breiting, & Rolls, 2009a, 2009b; McClaren & Hammond, 2005).

A second obstacle relates to teacher attitudes and competences. As McClaren and Hammond note:

Many teachers and faculty members have good reasons for not wanting to undertake environmental action projects with classes. While some are obviously concerned about lack of support from colleagues, administrators, or the community, or fear criticism directed at them

¹² Investigation, Vision, Action & Change (IVAC)

for radicalizing students and recruiting them to selected causes, other feel a lack of knowledge and skill concerning how to initiate and manage action projects, especially those that move beyond studying about action and begin to move into projects that entail learning through action (McClaren & Hammond, 2005, p. 281)

The challenge of teaching controversial issues has been dealt with in several studies. Grund & Brock (2020) summarize them in this way:

Many teachers feel they are frequently confronted with controversial issues but are ill-prepared for teaching them. They see great value in being able to address them better, especially on the basis of methods that foster multi-perspective thinking [82] (p. 24). Teaching such controversial issues “makes considerable demands on teachers, even under supportive conditions” [83] (p. 230). Not seldomly, these topics are seen as a risk for teachers for several reasons, and hence they try to avoid them [83]: they can lead beyond teacher’s expertise, to “inflammatory discourse” (ibid.) or to losing control over the classroom in terms of climate and discipline [84] (p. 17). Here, it is important to promote trust and provide room for emotional responses ([83], p. 230). A concrete didactical way of fostering multiperspectivity, highly relevant to ESD, is to use e.g., the constructivist method of structured academic/controversial dialogue, whereby learners have to reverse the roles they initially took in polar discussions on controversial issues [82].

Informed by research on socio-emotional education and the didactics of teaching controversial issues, careful dealing with these emotions and creating “emotionally literate classrooms” [85] is for example enabled by: supporting group cohesion through good relationships, creating an atmosphere that is warm and supportive, engagement in learning activities that are perceived as meaningful, and humor given its importance in bonding and building trust [83] (p. 248f) [85] (Grund & Brock, 2020).

As a teacher, working with real-world projects, you need a comprehensive competence profile, enabling you to work with interdisciplinary issues and/or you need collaborative competences to plan and conduct projects together with colleagues with other disciplinary profiles (Cook, 2015). Furthermore, you need competences enabling you to develop and facilitate processes, integrating learning and change together with local stakeholders. In this kind of collaboration, teachers cannot apply the usual ready-made methods, but have to align their methods with the interests and resources of stakeholders in the local community. Last but not least, working with participatory methods implies a difficult pedagogical dilemma between paternalism and laissez faire; too much teacher control will not allow the students to experience genuine participation, while a totally student-centred process risks reproducing students’ existing knowledge rather than moving beyond their cognitive horizon and thus enabling transformative and expansive learning (Læssøe, 2008).

A third type of challenge concerns student motivation for participating in action-oriented environmental projects. There are several cases of schoolchildren being strongly motivated by environmental issues in their communities, generated by clashes between what they learn in school and from media about climate change and biodiversity and juxtaposed with the lack of action they observe in their communities. These examples illustrate that schoolchildren and youth are able to act as activists, gain substantial successes and through this, develop their capacity and motivation for involvement in more environmental change projects (Bandura & Cherry, 2019). While these examples refer to children and youth who become environmental activists outside formal school settings, there is also research showing that action-oriented environmental projects in school settings may strengthen students’ motivation and learning (Breiting, Hedegaard, Mogensen, Nielsen, & Schnack, 2009). Furthermore, Bencze, Alsop, Ritchie, Bowen & Chen (2015) point to the advantage of students

dealing with issues they find meaningful, in that students work more in depth and seem more engaged with the issue. However, they also stress the importance of making appropriate support and guidance available to children, as they have noticed some fear and hesitation among children who have been encouraged to act. Participating children in their study tended to choose indirect action rather than action that confronted decision-makers. The authors suggest that feelings of helplessness, fear of consequences, and presumptions of not being taken seriously lead children to favor local communication rather than confrontive activism, when seeking to gain support for their opinions and raise awareness (ibid).

7.3 Citizen science and action-oriented environmental pedagogies

As described in chapter 3 of this report, citizen science originally referred to public participation in scientific research (PPSR). Since the Internet became common, citizen science has expanded dramatically. However, citizen science has also developed into various types.

In the field of environmental science, citizen science projects vary along four major axes: (1) initiator of the project, professional scientists or the public; (2) scale and duration of the project, whether local or global and short term or long term; (3) types of questions being asked, ranging from pattern detection to experimental hypothesis testing; and (4) goals which include research, education, and behavioral change (e.g. environmental stewardship) (Dickinson & Bonney, 2012 p. 5)

While 'science' in all these variations typically refers to natural science, other scholars stress that environmental issues calls for interdisciplinary, socio-scientific approaches to citizen science (Cook, 2015). The intention here is to ground scientific knowledge in relevant and meaningful contexts, to approach environmental issues as situated socioscientific matters. In relation to education, a socioscientific approach implies encouraging students to explore interfaces between science, society and technology. Furthermore, this perspective opens for action-oriented versions of citizen science where students become active participants and contributors in their local community (ibid). Citizen science, in this sense, enables interdisciplinary synergy between science education, environmental education and citizenship education (Wals et al., 2014).

Opportunities for linking social and ecological concerns in citizen science programmes has been addressed by several scholars. As will be shown in the following, this is not just approached as a technical matter but implies attempts to re-think science itself. Vallabh, Lotz-Sisitka, O'Donoghue & Schudel (2016) take their point of departure in Bruno Latour's distinction between 'matters of fact' and 'matters of concern'. Where conventional science tends to split the world up in bits in order to explore facts about each of them (i.e. matters of fact), issues regarding health, environment or social-ecological fields are characterized by 'matters of concern' (i.e. risks that concern citizens), which are of an entirely different character than matters of fact issues (Latour, 2004; Vallabh, Lotz-Sisitka, O'Donoghue, & Schudel, 2016). In line with this, Wals & Peters (2018) refer to calls for greater connectivity between science and society as 'mode 2 research' (Gibbons, 1999; Nowotny, Scott, & Gibbons, 2001). They do not see this as just another option, but rather as a necessary replacement of conventional science that gives rise to sustainability problems, with a sustainability science (Wals & Peters, 2018). In a similar vein, Vallabh et al. (2016) argue for the need to re-orient the epistemic cultures of science. In searching for such a re-orientation, they focus on 'citizen science projects in response to social-ecological risks', by which they mean citizen science projects that "respond specifically to different forms of socio-ecological risk such as biodiversity loss, water pollution and

climate variability” (Vallabh et al., 2016 p. 542). This links well with NBS as responses to ‘matters of concern’ around socio-ecological risks, as NBS implies a combination of ecological risks (biodiversity and climate change especially) in urban areas where solutions always also have social effects.

Vallabh et al. (2016) have developed an analytical model that differentiates ‘Seven broad purposes of social-ecological citizen science programs’ and orders them as follows:

1. Institutional or laboratory science
2. Geographic species mapping
3. Management of natural resources
4. Applied conservation action
5. Landscape-wide ecosystem monitoring
6. Community action, activism and learning
7. Situated and wider social learning (p. 543)

The following figure illustrates how these seven types of citizen science can be conceived as steps of expansions from the original idea of citizen science:

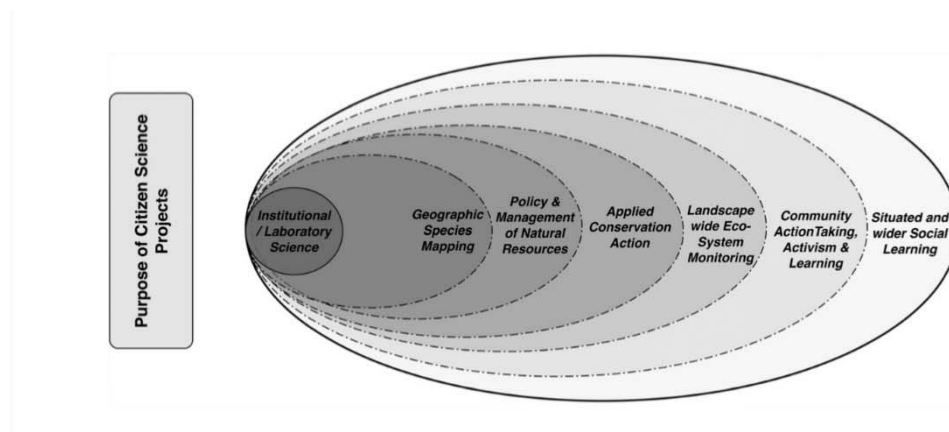


Figure 1. Heuristic and relational mapping of social-ecological citizen science project purposes.

(ibid p. 544)

In relation to NBS in urban areas, type 5, 6 and 7 are especially interesting:

- (5) “Landscape-wide ecosystem monitoring engage citizens in monitoring and civil actions across ecosystems (e.g. across a specific water catchment area);
- (6) Community action, activism and learning take action in response to specific socio-ecological risk (e.g. pollution affecting human health)(often initiated by civic groups or individuals);
- (7) Situated and wider social learning use citizen science as a tool for social or individual learning within a particular context” (ibid. 543)

The last two opportunities resemble what Wals and Peters (2018) describe as ‘Transition-oriented civic science’ characterized by scientist and lay people collaboration on lay people’s issues. Methodologically, type 6 and 7 link citizen science and action research. They take matters of concerns as their starting point and include citizen science as a tool to identify matters of facts (Vallabh et al. p. 547-548). While the ‘transition-oriented civic science’ presented by Wals and Peters (2018) has the character of a theoretically motivated ideal, Vallabh et al’s work (2016) is empirically grounded and

includes a few examples of type 6 and 7 in their typology. The combination of citizen science and action research has also been empirically explored by Marianne Krasny and Rick Bonney (2005).

Action research, with roots in the work of Kurt Lewin (Friedmann, 1987), has since the 1980s developed into a research tradition with several different versions (Reason & Bradbury, 2001). Krasny and Bonney draw on Participatory Action Research (PAR) which “attempts to engage local people in defining and conducting research with the goal of not only collecting data, but also educating community members about their current situation and engaging them in actions to improve local conditions” (2005, p. 292). A basic idea behind this is to create dialogue and knowledge exchange between participants’ local knowledge and scientific expertise. An important difference between this and other types of citizen science is that the process includes not only scientists and citizens but also other stakeholders of relevance for the action part of the project. This transboundary interaction is challenging, but one of the qualities of PAR is that it uses ‘hands-on’ methods like participatory mapping, diagram drawing and transect walks (an interview conducted while walking across a site), which is useful in situations where there are language differences between researchers and local participants (ibid. p. 293).

Krasny and Bonney highlight five challenges in combining large-scale citizen science with action research and educational purposes:

1. Balancing science and education
2. Ensuring data quality
3. Forming partnerships to enhance educational goals
4. Evaluating impacts
5. Building institutional support for citizen science (ibid. 296)

A central challenge is that you cannot expect that community members are interested in becoming co-researchers. This relates to the difficulty of explaining the participatory ideas of action research to people with conventional ‘deficit views’ of science and experts¹³ and points to the importance of being careful and giving time to adjust mutual expectations.

Krasny and Bonney (2005) also point to the importance of working closely with educators to develop materials that they can meld into their own programs. As they write:

Most of the literature on Citizen Science and Student-Scientist Partnerships focuses on the balance between the interests of scientists and students, rather than on the needs of educators. This in spite of the fact that teachers and/or non-formal educators are a critical element in these programs and that their needs and interests differ from those of students (Krasny & Bonney, 2005 p. 314).

One way to cope with this challenge is to establish a learning community in which educators are part of an informal ‘research/program development’ team “that plays a key role in setting program direction, designing implementing methods, and conduction the evaluation, with the goal of furthering our understanding of best educational practices” (ibid.).

¹³ According to Callon (1999) the *deficit model works from the premise that only scientists are able to grasp the full complexity of socioscientific issues. Under this model, exchange between scientists and citizens is predominantly unidirectional because the public is considered to hold a deficit of the scientific knowledge needed to shed light on the issue being debated.* (Cook, 2015)

7.4 NBS and education

While it is interesting to explore the potentials and challenges of combining citizen science and action-oriented learning in relation to NBS, it should not exclude an interest in other opportunities for combining NBS and education.

Several tasks in REGREEN, work package 5, are interested in schoolyards as spaces for learning. One way to frame it would be to regard the schoolyard as integrated part of a 'whole school approach'. The whole school approach is widespread globally, not least by the Eco-school programme, which involves thousands of schools all over the world (Lysgaard, Larsen, & Læssøe, 2015). Furthermore, in UNESCO's 'Global Action Programme on Education for Sustainable Development 2015-2019' the whole institution approach' was promoted as one of the five priority areas (UNESCO, 2013).

The whole school approach is basically a holistic approach in the sense that it does not only focus on curriculum development but also on school management, teacher competence, teaching methods, learning and work environments, the students, parents and the entire community.

One of the cornerstones of a whole school approach is an action orientation of student learning. It is therefore conducted in relation to practice – both within the school and in the surrounding society. The students are not provided with readymade solutions but supported in their participation in decision-making processes regarding both individual and collective actions (Lysgaard et al., 2015 p. 136).

Many eco-schools perform 'audits' of school grounds followed by implementation plans, monitoring and evaluation of progress towards sustainability (Tilbury & Wortman, 2005). Thus, in many cases, NBS education may become an integrated part of a school's gradual transition towards sustainability and their action-oriented approach to student learning as part of that.

The whole school approach positions the school as a lead agent that involves the local community in its sustainable transition. However, it may also be the other way around, where schools are invited to connect to ongoing sustainable transition processes in the local community as cases for exemplary learning (Negt, 1971). This has also been described as 'learning *from* sustainable development' (Katrien Van Poeck & Vandenabeele, 2012) and can obviously involve local NBS projects, whether they are conducted as integrated parts of municipality governance plans or as bottom-up 'civic ecology' projects (Læssøe and Krasny, 2015).

Finally, NBS education need not be part of a whole school approach or connected to ongoing local projects. Action-oriented NBS education may be conducted as singular educational projects or as case-based education.

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ⁱ Taken from Christina Toren's article, Imagining the World that Warrants out Imagination: The Revelation of Ontogeny (2012) *Cambridge Anthropology*, 30(1): 64-79.