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NBS EduWORLD Network Stream

NBS EduWORLD Living Labs Roadmap

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Abstract	This roadmap provides a comprehensive approach and structured path to embed environmental and social responsibility and active sustainability citizenship into school education through the integration of Nature-Based Solutions (NBS). It guides schools in reimagining infrastructure, curricula, teaching and learning, and community practices, inspired by nature and leveraging its power to solve real-world challenges. It aims to support the long-term strategy of mainstreaming NBS in education alongside the creation of vibrant, future-ready learning environments where sustainability is not just taught but is lived and practiced daily. Based on evidence and inspiring stories of implementation, it outlines objectives and key actions, highlights basic steps and lessons learnt, discusses opportunities and challenges, and explores the impact of setting up schools as NBS Living Labs for sustainability.
Keywords	Nature-Based Solutions (NBS), Education, Living Labs, Whole School Approach (WSA), Learning for Sustainability (LfS)
License	

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Abbreviations

CPD	Continuous Professional Development
CPL	Continuous Professional Learning
EC	European Commission
ECEC	Early Childhood Education and Care
EGD	European Green Deal
ESD	Education for Sustainable Development
ESG	Environmental and Social Governance
EU	European Union
GreenComp	European Sustainability Competence Framework
HE	Higher Education
HEIs	Higher Education Institutions
IBSE	Inquiry-Based Science Education
ICT	Internet Communication Technologies
JRC	Joint Research Centre
LfS	Learning for Sustainability
LL	Living Lab
NbI	Nature-based Infrastructure
NBS	Nature-Based Solutions
NGO	Non-Governmental Organisation
SD	Sustainable Development
SDGs	Sustainable Development Goals
STEAM	Science, Technology, Engineering, Arts, and Mathematics
STEM	Science, Technology, Engineering, and Mathematics
UN	United Nations
WSA	Whole School Approach

Executive Summary

Nature-Based Solutions (NBS) have emerged as a promising approach to addressing sustainability and environmental challenges, ranging from climate change mitigation and adaptation to human well-being and community collaboration, while providing educational opportunities. Opportunities to see environmental, climate change, and sustainable development education from a new, fresh perspective, and through the links NBS provide. Links to the development of competences, necessary for people to live, work, and act sustainably, to manage complexity and uncertainty, to collaborate and communicate effectively.

Therefore, in recent years, NBS has gained recognition as an effective tool and research topic for fostering sustainable development and creating resilient communities. Recognising the potential of NBS in educational settings, this document, a key output of the work carried out in the framework of the NBS EduWORLD project, and specifically within its “Education NBS Experts: Network Stream”, presents a roadmap on how schools can be transformed into NBS Living Labs.

The roadmap provides a comprehensive approach and structured path to embed environmental and social responsibility and active sustainability citizenship into school education through the integration of NBS. It guides schools in reimagining infrastructure, curricula, teaching and learning, and community practices, inspired by nature and leveraging its power to solve real-world challenges. Thus, the roadmap aims to support the long-term strategy of mainstreaming NBS in education alongside the creation of vibrant, future-ready learning environments where sustainability is not just taught but is lived and practiced daily. Based on evidence and inspiring stories of implementation, it outlines objectives and key actions, highlights basic steps and lessons learnt, discusses opportunities and challenges, and explores the impact of setting up schools as NBS Living Labs for sustainability.

The document is structured in five chapters, including the Introduction. Chapter 2 provides an outlook of the developed scenarios of plausible futures for NBS Living Labs in education and outlines the guiding principles for envisioning and building a roadmap for the NBS EduWORLD Living Labs, thus driving the work and actions to be carried out. Chapter 3 presents and describes in detail the key elements of the NBS EduWORLD Living Labs Roadmap, while providing evidence from stories of implementation. In addition, Chapter 3 takes a step forward by reflecting on the scenarios of plausible futures for NBS Living Labs in education based on the monitoring evidence. Chapter 4 guides schools on how to adopt the NBS EduWORLD Living Labs Roadmap and plan the actions needed to become hubs of innovation and sustainability through NBS. Finally, Chapter 5 summarises the document by providing conclusions that reflect on the future outlook and the viability of the Roadmap.

1. Introduction

The Nature-Based Solutions Education Network (NBS EduWORLD) aims to nurture an NBS-literate, inclusive, and sustainable society by building synergies between NBS professionals and education providers across sectors, formal and non-formal settings, and ensuring free and easy access to high-quality NBS knowledge resources. Through this work, communities can become more prepared, cohesive, and participatory in engaging with nature and use the benefits of nature to solve local and global challenges and improve public health and well-being.

NBS has emerged as a promising approach to addressing a range of environmental and societal challenges through the protection, restoration, and sustainable management of ecosystems. On the other hand, to achieve this and address these challenges, starting from schools, it is crucial to emphasise, enhance, and adopt policy instruments that promote NBS education and, in parallel, promote and support holistic schemes. In this way, both formal and non-formal education sectors could be enabled and motivated to provide NBS education within and beyond schools and educational institutions.

Box 1: Definition of Nature-Based Solutions

Nature-Based Solutions (NBS) are: "Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient, and systemic interventions. Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services."

Source: European Commission, 2022

Driven by policy, environmental, and economic imperatives, NBS education is increasingly emerging across disciplinary boundaries, knowledge silos, and skill sets to deliver integrated solutions to address the causes and consequences of climate change through education. These solutions can be delivered at a low cost compared to conventional infrastructure, broaden the scale of benefits for people and nature (Kapos et al, 2019), and, from an educational perspective, provide common ground to learners on the benefits of NBS to address sustainability challenges. At the same time learners gain the knowledge, skills, and attitudes that promote ways to think, plan and act with empathy, responsibility, and care for the planet and public health (Bianchi, Pisiotis, and Cabrera Giraldez, 2022).

In this context, the NBS Network Stream – the "Education NBS Experts" of NBS EduWORLD – demonstrates effective ways for the integration of NBS in school environments, based on the experience of teachers and school heads who are already implementing such innovative projects in their settings. Following a holistic methodology, they transform their schools into NBS Living Labs by introducing open innovation approaches and by nurturing meaningful collaborations between actors with diverging interests but with common objectives.

Box 2: Definition of the Living Labs

Living Labs (LLs) are: "open innovation ecosystems in real-life environments based on a systematic user co-creation approach that integrates research and innovation activities in communities and/or multi-stakeholder environments, placing citizens and/or end-users at the centre of the innovation process".

The concept 'Living Lab' is used for organisation that innovates according to these principles but also refers to innovation projects that follow these guidelines, and it links with specific activities, methods, and tools within these innovation projects.

Source: European Network of Living Labs

By monitoring the change in pedagogies, curriculum, infrastructure, teaching, and learning in these school settings, but also in other aspects of the school structure, like its vision, culture, and operations, the NBS EduWORLD Living Labs Roadmap was designed to be a useful guide for other schools and education stakeholders to follow.

2. Guiding Principles

This chapter presents the vision of the NBS Living Labs in education as a way to respond to emerging calls to action for mainstreaming NBS and contributing to Learning for Sustainability (LfS). It delineates the proposed methodology to be followed and the expected impacts on the communities inside and outside the schools, as well as the plausible futures for NBS Living Labs in education, as developed under NBS EduWORLD's deliverable D6.1[1].

All the above functioned as guiding principles for the project's implementation, and they can enhance the collective understanding of NBS in education and its future, supporting the vision of schools acting as NBS Living Labs and underlining the actions needed towards that vision. They nurture NBS in education, provoke 'what if' discussions, and delineate educational pathways. Ultimately, they are the cornerstones for the development of the NBS EduWORLD Living Labs Roadmap.

2.1 Green Learning Ecologies and the Role of NBS Living Labs

Formal schooling is one way people can learn about the existential challenges the world is facing, but also about the solutions that science and society can offer. It is organised and guided by formal curricula focusing on the acquisition of domain knowledge and scientific skills, leading to formal accreditation such as a diploma or certificate. While the central role of formal education is beyond doubt a significant part of competence development, skill acquisition, and personal growth, one needs to acknowledge that a big part of learning takes place outside of school. It results from daily activities related to family or leisure. In most cases, it is guided by

[1] https://nbseduworld.eu/fileadmin/user_upload/Resources/NBS_EduWORLD_D6.1_Scenarios-Plausible-Futures-NBS-Education.pdf

curiosity or interest and leads to enjoyment. Particularly young people learn in diverse places as they grow up, for instance within their families, their communities, through the media, in after-school programmes, or in the street. At the same time, they travel, and visit places like forests, parks, museums, and science centres. Sometimes – and ideally – they are confronted with and learn about the same concepts and phenomena in different learning contexts.

As a result, a significant challenge arises: How can we integrate the same concepts and phenomena they learn in these different contexts into a connected ecosystem? How can we create an effective learning continuum? While some research shows that people create links between different learning contexts (Eshach, 2007; Fallik, Rosenfeld, and Eylon, 2013), most of the literature points to a severe lack of contact between formal and informal learning contexts introducing the same concepts and phenomena (Kim and Dopico, 2016; Leonard, Fitzgerald, Kohlhagen, and Johnson, 2017). As out-of-school learning experiences become more common in people's lives (given the increased number of informal learning initiatives available), **it is crucial to facilitate stronger links and connections between the different learning settings and actors, that are often in the position to facilitate a "deeper learning" on environmental and sustainability issues in formal education in combination with activities and partners outside the classroom.** In essence, this is what Jackson and Barnett (2019) and Wals (2019) described as **learning ecology**.

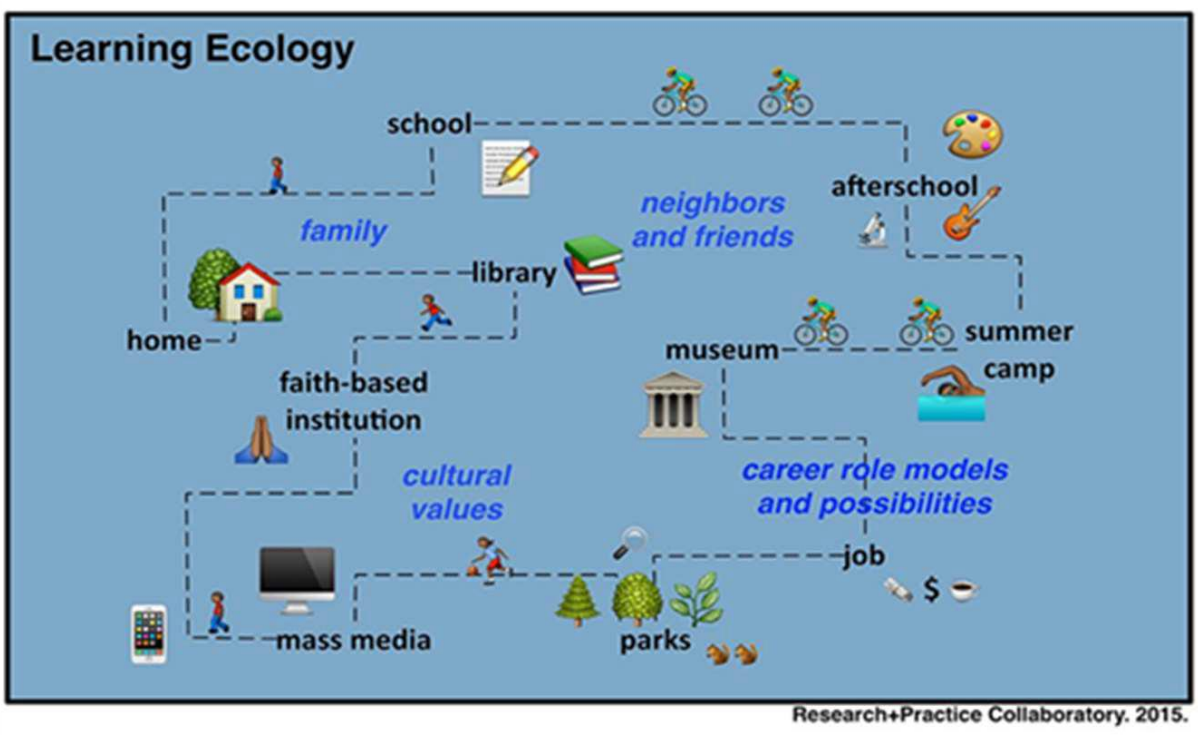


Figure 1: Graphical representation of a learning ecology that describes the learning paths in the framework of school and out-of-school learning activities.

In a learning ecology, participants from various backgrounds use diverse forms of learning and collaboration to create new meanings and understandings of the world and their own ways of thinking, being, and acting within it. A green **learning ecology is the physical, social, and cultural context in which learning for sustainability takes place**. Like natural ecosystems, green learning ecologies (Figure 1) have physical dimensions, which may or may not include

easy access to nature, natural history museums, or advanced environmental programmes or related activities.

By developing an appropriate osmosis process, there is a great opportunity to bridge the gap between the two worlds. A connected green learning ecosystem (e.g. by focusing on the effective integration of NBS) where young people may encounter a wide range of learning experiences and be supported by adults, scientists, and policy experts, as well as peers, in ways that could lead to future opportunities in personal, academic, professional, and civic realms. **This requires educators and organisations to think beyond the bounds of their institutions to consider how collective action at the level of networks can provide opportunities and address inequalities in a way that more isolated efforts cannot.**

To set into action such a process, we envision the transformation of the school environment to an NBS Living Lab that is embedded in the wider green learning ecology, demonstrating the way forward for both practice and research. When discussing how youth might thrive in such an ecosystem – and what sort of interventions we can develop to help all youth do so – the idea of pathways (Sotiriou, S., et al, 2017) has often come up as a useful metaphor that invites us to consider youths' "learning lives" over time and across the many contexts (e.g., home, school, community organisations, science centres and museums, web and social media) where learning may occur.

While there are many ways to productively conceptualise such pathways, we simply invoke pathways as a metaphor for thinking about ways to provide structure to youth experiences – Learning Paths – how they might "connect to" or "build upon" one another and thus allow a young person to pursue goals that require extended engagement or persistence across multiple contexts and learning opportunities.

Learning paths take many forms, influenced by emerging research and discoveries, changes in society's needs and interests, and shifts in personal interests or opportunities. Some individuals describe their learning path as an upward trajectory, pointed towards a clear goal. Others describe their path as more irregular, resembling steps or, more often, an erratic, bumpy line. Learning opportunities are made possible and shaped by the learning ecology one inhabits.

For practice, doing so implies that harvesting the transformative potential of teaching and learning in NBS Living Labs can benefit from a more systemic **Whole School Approach (WSA)**. Hence, schools need to "walk the talk" of sustainability and connect their external orientation of educating about and for sustainability with an internal focus on being (becoming) sustainable. This means coherently redesigning the purpose and practices of education, teaching and learning, of collaboration and co-learning with societal stakeholders; and of operations, management, and control (Wamsler et al, 2021). This pathway requires approaches that are relational in terms of connecting to others and to the environment, responsible in terms of addressing sustainability in a relevant and equitable way, responsive in terms of dealing with sustainability as an ongoing (learning) process characterised by continuous change and uncertainty; and emancipatory in terms of fostering self-determination, agency and an ethic of care for identifying challenges and exploring ways for addressing them (Wals, 2019).

For research, a learning ecology and ecosystem approach implies that developing a set of scientifically grounded guiding principles for sustainability-oriented teaching and learning in Living Labs calls for a more systemic understanding of where, when, how, and why teaching and learning in Living Labs fosters (or hinders) sustainability-oriented transformative learning (Tassone et al, 2023). Hence, this document empirically examines the characteristics of and experiences with education in Living Labs by focusing on the interplay between the Living Lab as a hybrid learning space, the approaches to teaching and learning used there in, the practices that foster collaboration and co-learning with societal stakeholders and the policies and structures of the school in which the Living Lab is embedded. By studying this, findings are brought together into this roadmap for designing sustainability-oriented, NBS education in Living Labs and promoting deeper changes in schools.

In the context of NBS EduWORLD, **a school as an NBS Living Lab** is both inward and outward-looking and open to create a healthy habitat that invites and supports NBS and sustainability. It has adopted the concept of **open schooling**[2] and it's an agent of community well-being by creating new partnerships with other local actors and addressing local issues relevant to them.

In a school as an NBS Living Lab, **students explore issues, relevant not only to themselves but also to others, while community partners can offer insights, but also benefit from students' interest, research, and creativity.** The students are more rooted in their habitat and gain a sense of place and connectedness.

Teaching and learning are interdisciplinary and transformative. The learning methods and approaches are collaborative, experiential, inquiry and problem-based, practically oriented, and relevant to local contexts. Much of the learning does not take place inside the classroom, but also in other spaces inside and outside the school building, as well as in the local community, in the marketplace, at the library, the museums, and through playing, reading, and sports activities. The boundaries between formal, informal, and non-formal learning are indistinct.

Basic pillars of education, such as design, content, and assessment for each topic, are reflected throughout the curriculum, considering the competences being developed. The development of the knowledge, skills, and attitudes of learners of all ages to live and act sustainably is supported by the **GreenComp**[3]**,** the European sustainability competence framework, which has been designed to support education and training programmes for lifelong learning.

A school as NBS Living Lab, acts as a learning space for sustainability. For example, it operates an organic school garden that, apart from acting as an open educational environment for all students, produces a significant amount of vegetation consumed in the school canteen. It reconstructs the schoolyard in a green space, and therefore a "cool island" during heatwaves, with the participation of students and external stakeholders in its co-design, the selection of the plants according to their characteristics, and the planting process. Thus, apart from acting as an educational environment for all students, it reduces runoff, helps filter pollutants, and enhances biodiversity by providing food and shelter for butterflies, songbirds, and other wildlife.

[2] https://publications.europa.eu/resource/cellar/0c001712-4598-11eb-b59f-01aa75ed71a1.0001.03/DOC_1
[3] https://joint-research-centre.ec.europa.eu/greencomp-european-sustainability-competence-framework_en

It controls energy and rainwater runoff by using NBS that its students have studied, experimented with, and proposed. By interrogating, rethinking, and redesigning institutional and teaching practices, the hidden curriculum of unsustainability that is often present can be exposed and addressed.

In a school as NBS Living Lab, all educators, whatever their discipline or sector of education, are considered sustainability educators who need to support their learners in preparing for the green transition. For this reason, they have the expertise and continuous training opportunities to feel sufficiently equipped. Professional development is also relevant to all staff groups working at schools, such as those who clean the building, run the school canteen, maintain the buildings and the school grounds, etc.

Becoming an NBS Living Lab cannot be seen as an isolated "project", as it demands a root and branch rethink, not just in pedagogies or the curriculum, but in every aspect of the school structure: its vision, culture, and the use of space, place, and time. Similarly to the Open Schooling concept, a school must act as an open, curious, creative, welcoming, and democratic environment that is supposed to support the development of innovative educational activities (Sotiriou et al, 2021).

To this end, the vision of the NBS Living Labs is to create seamless and continuous learning pathways at all education levels, nurturing in parallel the understanding and implementation of NBS. By incorporating NBS principles and practices into the curriculum, students develop the key competences toward pro-environmental behaviour and action for addressing complex sustainability challenges.

Under this vision, a planning exercise was conducted under deliverable D6.1: Scenarios of Plausible Futures for NBS in Education[4] for primary and secondary schools aimed to represent schematically the vision of the schools as NBS Living Labs through a WSA.

Box 3: Structure of the diagram for integrating NBS through the WSA in the schools

For each grade, an NBS topic was chosen. Each NBS topic was linked to:

- the existing curriculum,
- various learning methods and approaches through different activities,
- potential stakeholders who will be involved,
- the societal challenges that will be addressed,
- the school building and the learning opportunities from this linkage,
- the necessary career professional development courses.

The compiled diagram (Figure 2) was intended to serve as a point of reference and provide guidance for the transformation of the schools into NBS Living Labs through the WSA.

[4] https://nbseduworld.eu/fileadmin/user_upload/Resources/NBS_EduWORLD_D6.1_Scenarios-Plausible-Futures-NBS-Education.pdf

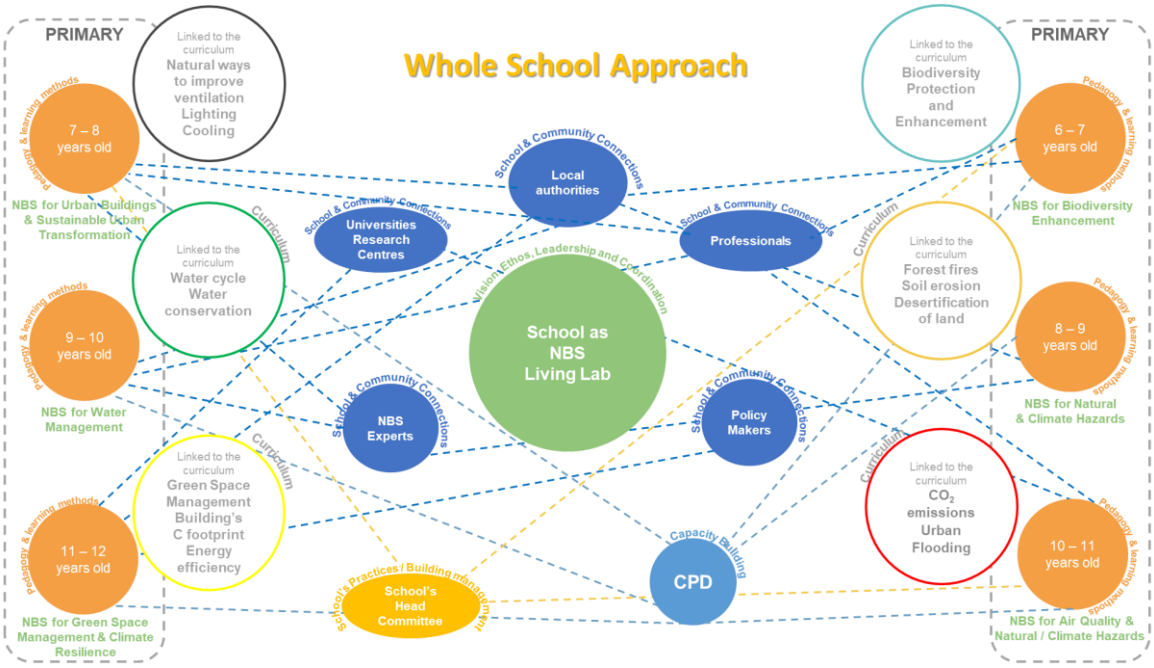


Figure 2: Diagram for integrating NBS through the WSA in the primary school
Source: NBS EduWORLD Deliverable D6.1: Scenarios of Plausible Futures for NBS in Education[5]

2.2 The Role of NBS Living Labs in Learning for Sustainability

LfS possesses specific characteristics that seek to provide learners of all ages with the mindset and tools necessary to identify what in our lives, schools, and communities is unsustainable, and to work towards change for a more sustainable future. LfS also equips them with skills and competences that enable them to facilitate social, economic, and environmental changes that support the green transition. Although the green transition and ecosystem challenges are the main entry points for LfS, it needs to be seen in relation to all the dimensions of sustainability. Ultimately, LfS is about (1) learning how to change individual life choices and professional practices, and (2) learning to influence the social, economic, and system changes needed to affect the green transition (Mulvik, Torres, Chachava, Lekavičiūtė et al, 2024).

Box 4: Definition of Learning for Sustainability (LfS)

Learning for Sustainability is defined as: "Holistic and interdisciplinary learning experiences that enable learners to embody sustainability values, vision and mindset, as well as to understand and critically analyse complex economic, environmental and social systems, to live and work sustainably, contribute to the green transition and to actively participate in restoring and maintaining ecosystems and taking individual and collective action for a sustainable future for all."

Source: European Commission, 2024

To highlight the role of NBS Living Labs in LfS, it is crucial to focus on the concepts included in the definition of LfS. In essence, LfS takes the form of holistic interdisciplinary learning

[5] https://nbseduworld.eu/fileadmin/user_upload/Resources/NBS_EduWORLD_D6.1_Scenarios-Plausible-Futures-NBS-Education.pdf

experiences coupled with action-oriented, transformative pedagogy that helps learners to understand the root causes of unsustainability and how to act to address them.

Although the study by Marlies L.E. van der Wee et al. (2024) for Living Labs refers to higher education, it gives a very aligned description of the learning that could happen in NBS Living Labs. In this context, Living Labs are engagements with the real world, enabling students to work on real-world challenges that address the needs in a particular context, such as a project to promote low-carbon mobility and transportation (Larsson and Holmberg, 2018) or a drought monitoring and preparedness program (Brundiers et al, 2010). Such challenges are characterized by a certain level of complexity and uncertainty and are turned into assignments such as design or research projects. Students also engage with real-world stakeholders from business, government, non-governmental organizations, and civil society (Eriksson et al, 2015; Evans et al, 2015). Depending on the challenge, stakeholders have a role as a client, partner, or user in their relationship with the students.

Learning in NBS Living Labs enables students to increase their capacity to **address sustainability challenges**. For example, Backman et al. (2019) and Wals (2019) indicated that learning in Living Labs can support students in understanding the complex nature of sustainability, building agency, tackling challenges collaboratively with stakeholders from different backgrounds, and experimenting with new sustainable practices. Through experiential and collaborative learning in design projects, students learn how to develop practical solutions while considering the complexity and contextuality of a challenge. This capacity is, for example, reflected in students' work on prototypes for climate-responsive buildings (Dabaieh et al, 2017). Also, learning in NBS Living Labs allows students to develop their capacity to **manage complexity, uncertainty, and ambiguity**. For example, collaborative project-based learning enables students to learn how to work iteratively across different angles and features, as well as to become competent in exploring, discussing, and integrating diverse and sometimes contradicting perspectives.

In addition, learning in NBS Living Labs empowers students to **act as change agents for sustainability**. By performing activities like collaborating with residents, experiencing alternative eco-responsible practices, and participating in workshops about grassroots innovations, students learn to denormalise taken-for-granted practices, trust alternative methods, and address challenges unconventionally. This capacity manifests itself, for example, when students collaborate with community activists to promote socially just urban planning (Peterson, 2018).

Furthermore, learning in NBS Living Labs enables students to develop their capacity to **collaborate and communicate effectively**. In collaborative experiments on school or partnerships with residents, students learn how to organise teamwork, deal with different perspectives and views, and communicate ideas with diverse audiences. The most often assessed competence, in NBS education, is collaboration[6]. Students' capacity comes forth when they work as a team (Zen, 2017), deal with difficult and frustrating team processes (Hector and Kohtala, 2022), present their work to different audiences (Illes and Kristianova, 2022), or collaborate with residents on equitable local services (Thorpe and Rhodes, 2018).

[6] https://nbseduworld.eu/fileadmin/user_upload/Resources/NBS_EduWORLD_D2.2_Assessment-Framework-Guidance.pdf

Learning in NBS Living Labs also enables students to increase their capacity to **think and reflect critically**. By participating and collaborating in sustainability initiatives (Jernsand, 2019), engaging in introspective practices (Roysen and Cruz, 2020), or imagining possible futures (Holmén et al, 2021), students learn to engage with socio-ecological issues ethically and to question the desirability of actions from the perspective of social and environmental impact. Students' capacity becomes visible in their work through, for example, more socially aware action plans (Lake et al, 2016) or knowledge of marginalized issues and perspectives (Hector and Kohtala, 2022).

Finally, learning in NBS Living Labs enables students to **develop personally**. This can be through nature-based collaborative experiences, student-led discussions, or introspective storytelling, all of which help students develop self-confidence to pursue ideas (Roswag-Klinge et al, 2019), a sense of care for other people and the environment (Ramchunder and Ziegler, 2021), and open-mindedness toward other perspectives (Lake et al, 2016).

To this end, the role of NBS Living Labs in LfS should be highly considered, especially examining all the above through the lens of Section 2.1 – approaching the NBS Living Labs as a learning ecology that is embedded in the wider ecosystem of a school, which follows a systemic WSA.

2.3 Whole School Approach: The Driving Force of NBS Living Labs

A WSA provides a framework for reorienting and redesigning education, considering the emerging global sustainability challenges. It is an integrated approach in which all educational processes that influence learning are addressed, and it invites a holistic, systemic, co-creative, and reflexive effort by all stakeholders involved in education to meaningfully engage students. The approach encompasses teaching and learning, vision, planning and governance, active learner and staff participation, involvement of families, management of buildings and resources, and partnerships with local and wider communities.

Box 5: Definition of the Whole-School Approach

The Whole-School Approach to Sustainable Development is**:** "a framework that supports schools in giving shape to education for a sustainable future, in consultation with all stakeholders and interested parties in and around the school. The WSA helps to integrate sustainability issues structurally and coherently into the school organization." A **Whole-School Approach** to sustainability seeks: "to embed learning for environmental sustainability across the institution. It adopts a systemic view of education creating opportunities for living and learning sustainability across the education environment."

Source: European Commission 2022, Leren Voor Moorgen

Through a WSA multiple themes can be simultaneously addressed within the overarching umbrella of "sustainability" or "sustainable development," not by reducing them to "learning tasks", but as entry points to different ways of working and living, in light of current global challenges (Mathie and Walls, 2022).

Analysing some theoretical aspects of WSA and how NBS can strengthen WSA, a whole-school and interdisciplinary approach that includes students, teachers, families, and the broader community can help create a cultural shift towards a more sustainable future (Borgonovi et al, 2022). Hence, the creation of continuous learning pathways that begin in primary education and continue in secondary education is of paramount importance to ensure that young people are prepared to meet future sustainability challenges.

Tilbury and Galvin's (2022) input paper and Mathie and Wals (2022) highlight that WSA is the key to LfS, and to apply it, important starting questions need to be addressed by the school community. Figure 3 presents how the NBS Living Labs address these questions.

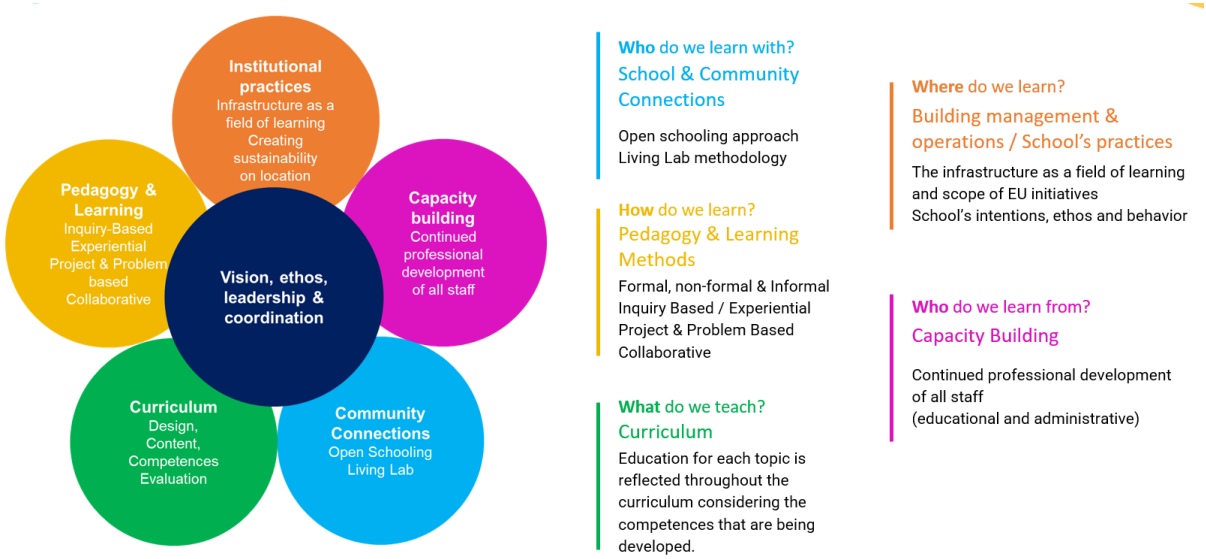


Figure 3: NBS as enabler of the WSA

Grounded on the pillars of the WSA, the NBS Living Labs can significantly contribute to establishing more engaging and impactful learning opportunities for NBS education, acting as dynamic spaces for experimentation and innovation.

WSA emphasises the comprehensive integration of NBS principles into all aspects of a school's functioning. It goes beyond merely incorporating NBS into the curriculum and extends to various school activities, training opportunities and capacity building, infrastructure, community engagement, the vision, and leadership of the school. Detailed analysis is provided in the NBS EduWORLD deliverable D6.1: Scenarios of Plausible Futures for NBS in Education[7].

2.4 NBS Living Labs in Education: Scenarios of Plausible Futures

NBS EduWORLD's focus is on mainstreaming NBS in education. To support this from a long-term perspective, a scenario-planning exercise was conducted under deliverable D6.1:

[7] https://nbseduworld.eu/fileadmin/user_upload/Resources/NBS_EduWORLD_D6.1_Scenarios-Plausible-Futures-NBS-Education.pdf

Scenarios of Plausible Futures for NBS in Education[8]. The scenarios were used to identify key "drivers," uncertainties, baselines, constraints, opportunities, and potential points of mainstreaming NBS in education. They were meant as a perspective on NBS in education to help provoke "what if" discussions, discuss critical factors, and develop the NBS EduWORLD Living Labs Roadmap. The aim was to improve the collective understanding of the development of NBS in education and its plausible future. This, in turn, helped improve the vision of schools as NBS Living Labs and our understanding of the actions necessary for working towards the vision.

In scenario 1, "**Flourishing from inside out"**, innovative schools, which already have a vision and effective leadership, follow the WSA and are transformed into NBS Living Labs, showing the way. The scenario outlines a more individualistic approach with schools as initiators, designers, and leaders of the processes, and limited supportive policies (Figure 4).

In scenario 2, **"Open the way from outside in"**, Ministries, Directorates, Municipalities, or Organizations develop a stepwise design to scale up NBS in education, establishing the schools as NBS Living Labs. They develop comprehensive frameworks that integrate NBS principles into the curriculum at all educational levels. The transformation comes through policy integration, capacity building, funding mechanisms, and collective knowledge exchange and networking. Thus, it describes a framework in which a strong governance structure co-exists with supportive policies.

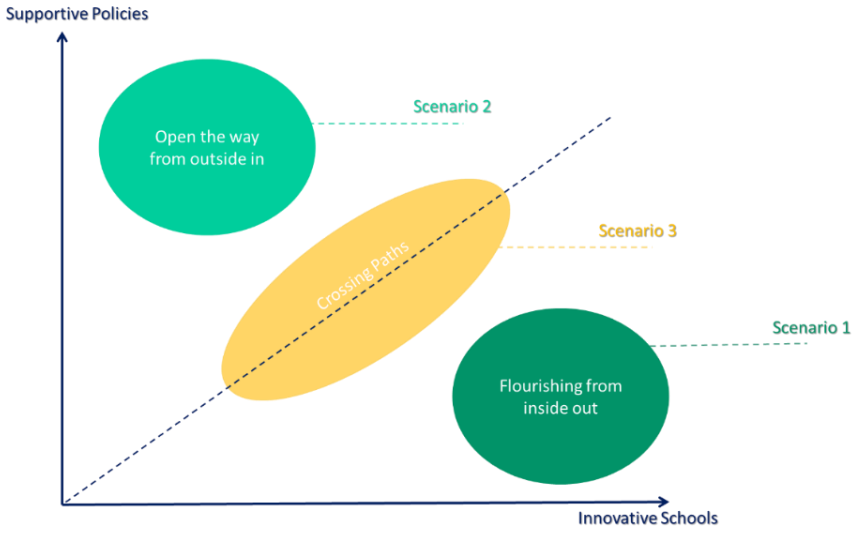


Figure 4: The scenarios as a function of supportive policies and innovation in schools[8].

In scenario 3, **"Crossing Paths"**, a hybrid situation is presented, in which supportive policies, teachers' engagement, innovation in schools, and up to a point, collaborative action coexist (Figure 4). Individuals, NBS experts in their field, teachers and school principals, and professionals outside the school meet each other or follow an initiative, policy, or framework, and in this way, transform schools into NBS Living Labs following the Whole School Approach. Detailed analysis of the scenarios is provided in the deliverable D6.1[8].

[8] https://nbseduworld.eu/fileadmin/user_upload/Resources/NBS_EduWORLD_D6.1_Scenarios-Plausible-Futures-NBS-Education.pdf

3. From Scenarios to Practice: The NBS EduWORLD Living Labs Roadmap

The NBS EduWORLD Living Labs Roadmap was designed and developed to support the long-term strategy of mainstreaming NBS in education alongside the creation of vibrant, future-ready learning environments where sustainability is not just taught but is lived and practiced daily. Based on (a) the guiding principles as analysed in Chapter 2, (b) the monitoring of nine schools in Greece (Annex 1) that acted as case studies, and (c) the overall work carried out in the framework of the project, the roadmap proposes a concrete overview of the implementation of the WSA for establishing the NBS Living Labs, offering in parallel a description of the steps that schools will need to take in order to become innovation hubs for the green transition. Therefore, the roadmap must be used in conjunction with the guiding principles outlined in Chapter 2 and the supporting guidelines and materials provided in Chapter 4.

The implementation work with the schools offered the opportunity to test the effectiveness of the proposed roadmap and reflect on the scenarios of plausible futures of NBS in education. The scenarios presume that schools are transformed into NBS Living Labs following the WSA, guided by the existing level of innovation and the existence of supportive policies and initiatives. The qualitative research, conducted through practice reflection and summative workshops, interviews, observations and document analysis, like action plans, reports and presentations of the schools (Annex 2), helped the authors to position the 9 schools in the graph "The Scenarios as a function of supportive policies and innovation in schools" (Figure 4), before and after their involvement in NBS EduWORLD and the one-year intervention (Figure 5).

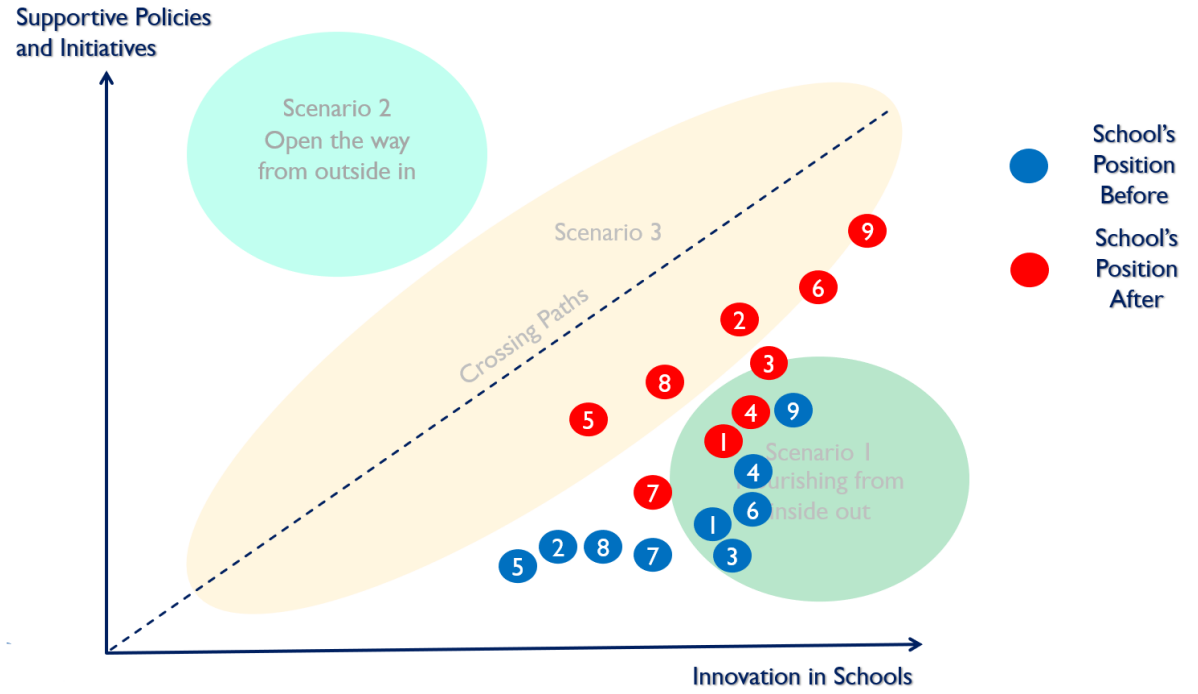


Figure 5: The initial and final position of the 9 schools involved in NBS EduWORLD

It has to be noted though that the nine schools were selected based on their innovative character and their readiness to act as reference schools for the NBS EduWORLD schools' community that was developed in the framework of NBS EduWORLD's work with educators with little to none, or advanced knowledge of NBS. For this reason, these schools are located (initially) at the lower part of the graph.

Through the conducted analysis, it appears that the higher the level of supportive policies and initiatives in place and followed by innovative schools, consisting of or led by NBS expert teachers/principals, the level of innovation increases, also moving the plausibility of NBS in education towards the scenario 3 **"Crossing Paths"**. In fact, the level of innovation increases significantly in less innovative schools. The key point is that although top-down (Scenario 2) and bottom-up (Scenario 1) approaches represent contrasting strategies, their combination in a balanced way (where the strengths of one approach overcome the weaknesses of the other) could catalyse the diffusion of innovative concepts and ideas (like the Nature-Based Solutions) in the traditional school environments. As we will see in the following paragraphs when local, context-specific needs and initiatives of the school communities are integrated to standardised approaches driven by the EU or the national educational authorities, the potential of the process to bring sustainable change is unique.

Scenario 3, "Crossing Paths," proves more plausible since most schools are moving towards this area of the graph after the implementation phase. Two key driving forces form the overall result as presented in Figure 5. The adoption of the WSA approach (through the continuous support mechanism provided by the project team) by the participating school communities which contributes to the introduction of an innovative culture (horizontal displacement), and the number of policy initiatives at both EU (strategy focusing on NBS and Climate Change, the introduction of GreenComp Framework) and national level (e.g., the implementation of a large-scale national initiative focusing on Active Citizenship[9] promoted by the Institute of Educational Policy that includes extended references to sustainability citizenship, the implementation of the large scale 2MEuro initiative on school gardens for 4.384 schools[10] etc.). The vertical displacement was based on the level that the local school communities have adopted the different policies in the framework of the school practice, both at organization level and at the teachers and students' level.

Even in cases where the level of supportive policies and initiatives increases to a low extent, leaving some schools in scenario 1, "Flourishing from inside out", all nine schools are moving towards scenario 3. The project team also designed the two major activities of the NBS EduWORLD Academy in July 2024 and July 2025 to promote and highlight these contributing forces to bring to scale school-based innovation (by demonstrating the movement from Scenario 1 to Scenario 3) and to create opportunities for sustainable change in the school environment. The courses included extended informative sessions about the policy initiatives and numerous demonstrations on how the participating teachers and school heads could turn these policies into practical actions in their schools. Figure 5 graphically represents these major impacts of the project approach.

[9] https://www2.iep.edu.gr/el/aeiforia-energos-politeiotita-active-citizenship
[10] https://dipe.sam.sch.gr/λαχανόκηποι-στα-σχολεία-με-κριτική-σκ/

In addition, following the WSA has an obvious impact on the openness of the schools, the integration of NBS education, and the level of innovation, transforming them into NBS Living Labs. It appears that schools that embraced the WSA at a higher level, consistently following and working on more or all its pillars, showed a higher level of innovation and integration of NBS. This was evident from the study of their journey in NBS EduWORLD.

This study of journeys led to the NBS EduWORLD Living Labs Roadmap (Figure 6) to provide a structured step-by-step path for embedding environmental and social responsibility, and active sustainability citizenship into schools through the integration of NBS, and guide them in rethinking education through the lens of nature to solve real-world challenges.

Figure 6: NBS EduWORLD Living Labs Roadmap: Key Pillars

3.1 Envisage an Open School for Open Minds and Open Societies

Becoming an NBS Living Lab, needs to be seen through the lens of an Open School, an innovative ecosystem, which acts as a shared site of learning for which leaders, teachers, students, and the local community share responsibility, over which they share authority, and from which they all benefit through the increase of their communities' science capital and the development of responsible citizenship.

Key steps towards an Open School as NBS Living Lab:

- Shape a clear vision and strategy (School Action Plan) detailing how the school will follow a WSA to become an NBS Living Lab, which promotes sustainability (§3.1.1).
- Design and follow consistent strategies to encourage active sustainability citizenship and the development of life competences (Green and 21st Century) (§3.1.1).

- Support the development of an interdisciplinary environment where students and teachers are encouraged to try and share new ideas and approaches, develop innovative projects, and identify and collaborate with other schools for new projects (§3.1.1).
- Rethink the school's teaching and learning practices and build an NBS curriculum embedded in every aspect of the school, having the "green learning ecology" idea as a lighthouse to guide.
- Promote collaboration with non-formal and informal education providers, municipalities, professionals, enterprises, and civil society organisations, and be engaged in projects which demonstrate external stakeholders' involvement. To do so, the Living Lab methodology, as presented in NBS EduWORLD, is proposed (Figure 7) (§3.1.2).
- Work on parental engagement in school projects (§3.1.3).
- Invest in professional development of teachers and school heads to enhance cognitive learning, foster change in behaviour, and the adoption of an open schooling culture and philosophy.
- Cultivate positive thinking and empower students and teachers based on community-building mechanisms and inspiring stories of implementation.

Figure 7: The Living Lab methodology as proposed in NBS EduWORLD

3.1.1. Develop shared responsibility for student learning

The first thing to consider when envisioning an open school as NBS Living Lab is that a learning culture must be established, which values the need to learn, as well as students' need to learn how to learn, to become self-directed, and to develop a sustainability mindset. This culture is established through the creation of a clear and visible set of core values, which are then reflected in the design of the school, the way students are introduced to and oriented to the school, what is assessed and valued, and the consistency governing all the aspects of the school.

An understanding and reflection of these core values can be seen in everything, from the language that teachers and students use to talk about LfS and their attitudes and behaviour within or outside the school, to the way the school interacts with the community. The corresponding condition in support of teaching for sustainability and NBS is a culture in which everyone is collectively responsible for student learning. This culture must be purposefully established for learners and educators alike and is commonly developed by building relationships that ensure learners are well-known by both adults and peers, and that there are regular and systemic opportunities for frequent conversations among educators, learners, peers, and other adults beyond the school.

Therefore, the school should:

- Make a regular audit of the school's needs in the direction of sustainability, involving students, teachers, and staff.
- Have an atmosphere that allows everyone to feel that they can contribute innovative ideas and proposals without fear. School leadership has a particular role in facilitating this.
- Decide every year what the new challenges are and what actions are to be taken for the continuous improvement of the school.
- Strives to be an example of careful management of resources.
- Provides evidence of the results obtained to the internal and external community.

3.1.2. Extend learning beyond the school

To connect learning to real issues and settings to make it more meaningful for students, schools must ensure that there are frequent opportunities for students to experience workplace conditions and expectations and address real-world challenges and problem-solving by interacting with professionals and experts in NBS and sustainability-relevant fields, taking on a professional role when doing a project. In addition to connecting to the "real" world, teachers in open schooling environments find ways to extend learning beyond the school and construct powerful student learning experiences in a range of settings within the local community.

As a result of long-term formal and informal relationships with local municipalities, authorities, businesses, institutions, and community groups, local, national, or international networks, the classroom walls drop away and the entire community becomes an annex of the school in which students have access to rich content, outside experts, additional resources, an authentic place

and context for learning, and work-based experiences. This extends to cooperation with other schools to develop, exchange, and compare ideas and information.

The crucial aspect for schools to consider is that the developed relationships must go beyond financial and technical support. In an open school as NBS Living Lab, students become part of the real world, exploring issues relevant to real-world challenges and proposing solutions; therefore, external community partners can offer insights, but also benefit from students' interest, research, and creativity.

3.1.3. Work for effective parental engagement

Open Schooling, as defined by the European Union (European Commission, 2015), is when educational institutions partner and engage with families and local communities to enhance teaching and learning. Parents must be an integral part of an open school as NBS Living Lab. Not only does this have a tangible impact on their relationships and thoughts for the school staff and their children, but it also contributes to the effective implementation of the open schooling strategy.

For effective parental engagement, schools must consider:

- Appropriate Planning: Parental engagement must be planned for and embedded in the whole school strategy. The planning cycle must include a comprehensive needs analysis, the establishment of mutual priorities, ongoing monitoring and evaluation of interventions, and a public awareness process to help parents and teachers understand and commit to this strategy.
- Effective Leadership: Effective leadership of parental engagement is essential to success. A parental engagement programme must be acknowledged by all the school staff and is often led by a senior leader, although leadership may also be distributed in the context of different thematic areas working in a clear strategic direction.
- Collaboration and Engagement: Parental engagement requires active collaboration with parents and should be proactive rather than reactive. It should be sensitive to the circumstances of all families, recognise the contributions parents can make, and aim to empower parents.
- Sustained Improvement: A parental engagement strategy should be the subject of ongoing support, monitoring, and development. This will include strategic planning, which embeds parental engagement in the school development plans, sustained support, resourcing and training, community involvement at all levels of management, and a continuous system of evidence-based development and review.

3.1.4. Inspiring Stories of Implementation

The schoolyard in the **Primary School of Zacharo** (Annex 1), once a neglected and cemented area, was reimagined as ground for transformation, not only of the physical environment but also of the school's educational culture, driven by the principal's vision for the school's development and her belief in education for sustainability and NBS.

Actions towards the openness of the school and connections with the community

Local Authorities: The Municipality of Zacharo played a vital and responsive role from the beginning. Whenever the school requested help, such as workers, soil, tools, or financial support, the Municipality responded positively and promptly. Although official protocols sometimes imposed delays or limited flexibility, the spirit of cooperation prevailed.

Parent Association: The Parents' Association was instrumental, both symbolically and practically. They donated the school's first composter, and they encouraged, advised, and worked where needed.

External Professionals shared knowledge and sparked inspiration.
- Agronomists and agriculturalists visited the school to answer student questions and provide guidance on planting strategies.
- A specialist in traditional seeds hosted a workshop explaining the value of heirloom varieties versus hybrids.
- A regional pasta producer came to the school to cook meals using vegetables from the garden.
- A community member organized a session on creating a seed bank and gave a talk on plant heritage, encouraging stewardship of local plant diversity.

School Staff Involvement and Cooperation: Although the project originated in the context of the "Skills Lab", it quickly expanded into an interdisciplinary experience. Teachers of English, Art, Math, ICT, Physical Education, and even non-teaching staff, such as the school guard, contributed. The guard, for example, inspired and helped implement a vertical strawberry garden within the school garden.

Local Community: The primary school in Pelopio, a neighbouring school, began its own garden initiative after visiting Zacharo. Through online meetings and onsite exchanges, the school shared knowledge and experiences.

Research and Scientific Organisations: The initiative was inspired after the Vice Principal and teachers' participation in NBS EduWORLD's International Professional Development Course 2024, organised by Ellinogermaniki Agogi's Research & Development department. The collaboration with and support by Ellinogermaniki Agogi and NBS EduWORLD continued throughout the year of implementation. The success of the garden project inspired the school's first-ever summer school entitled "Sustainable Food Systems", organized with the support of Ellinogermaniki Agogi and the Hellenic Association of Physicists. Over three days, 25 students and 10 teachers explored topics such as the environmental footprint of food production, conducted experiments (e.g., sugar in soft drinks), and participated in workshops at a local farm and the Botanic Garden of Ancient Olympia.

The principal of the **1st Upper Secondary School of Lamia**'s (Annex 1) vision to bring NBS to the school, as well as the desire to counteract the monotony and disengagement that many upper school students feel in an exam-focused system, led to an outdoor renewal. By integrating different actions related to NBS, the school tried to spark curiosity and purpose.

Actions towards the openness of the school and connections with the community

Local Authorities: The school maintained an open dialogue with the Municipality of Lamia, particularly in the shared goal of improving the school's visual and environmental impact. Plans for a vertical garden on a graffiti-covered wall were co-developed. Although the plans faced repeated setbacks, the municipality remained engaged, proposing solutions such as anti-graffiti coatings to achieve the plans.

Plants, soil, and gardening tools provided by the parents

Meeting with the Mayor of Lamia
'Shaping the future of the municipality together'

Parent Association: Parents, especially those with connections to local plant nurseries, donated plants, soil, tools, and guidance, helping the school overcome financial obstacles.

School Staff Involvement and Cooperation: At the high school level, there is no "Skills Lab" in the curriculum and no hours dedicated to projects. Still, teachers from all disciplines collaborated and worked even in after-school hours.

Peer Learning from the NBS EduWORLD Community: The school, as a first-time participant in such an initiative, drew ideas and courage from other schools in the network. Through the workshops conducted and the exchange of challenges commonly faced, it was discovered that they are not alone.

The principal of the **6th Lower Secondary School of Volos** (Annex 1) is an NBS expert teacher, involved for many years in initiatives related to sustainability and NBS. She has contributed to various changes in the schools where she has worked. In the 2023-24 school year, she moved to the 6th Lower Secondary School of Volos. This was a new challenge for her to transform the school into an NBS Living Lab by reconstructing the schoolyard and creating a school garden.

Actions towards the openness of the school and connections with the community

Local Authorities: The Municipality of Volos helped the school by cleaning the outdoor areas, pruning the trees, and providing flowers and plants.

Parent Association: The Parents' Association offered voluntary work and bought various things, such as the slabs for creating the garden corridors. Additionally, one parent provided a substantial contribution to the construction of a Sustainable Drainage System, and others provided their professional guidance as agrologists.

Research and Scientific Organisations: The principal and vice principal participated in the NBS EduWORLD's International Professional Development Course 2024, organised by Ellinogermaniki Agogi's Research & Development department. The collaboration with and support by Ellinogermaniki Agogi continued throughout the year of implementation. Cooperation was developed with the Universities of Thessaly and Athens, with continuous updates on sustainable development.

Local Community: Local media covered the transformation and informed about the actions. Seeing the daily care and transformation, neighbours began to initiate conversations with the school. The school principal invited them to help water the garden during the summer break, and they happily agreed.

International Collaborations: When schools from Türkiye, Malta, and Portugal visited the school within the framework of the ERASMUS+ programme, a dedicated session was held where all participants planted together.

The **4th Primary School of Pefki** (Annex 1) is one of the schools that collaborated with the peripheral NBS EduSystem, the Municipality of Lykovrysi-Pefki. As part of its collaboration with NBS EduWORLD, the municipality promoted the initiatives "Greening the Municipality by creating a Positive Environmental Balance" and "Adopt your tree", encouraging citizens of all ages to participate in sustainable practices. It also created engaging educational programmes for local schools and residents, aimed at fostering environmental responsibility and stewardship. The school is a member of the Eco-Schools Programme and participates in various initiatives related to environmental and sustainability education. The principal, along with an expert teacher, embraced the municipality's initiative from the beginning, making efforts to take the initiative one step further and turn their school into an NBS Living Lab.

Actions towards the openness of the school and connections with the community

Local Authorities: As already mentioned, the Municipality of Lykovrysi-Pefki, with the Mayor leading and actively and continuously supporting the initiative, including the Deputy Mayors of Urban Planning and Greenery, and the Department responsible for tree planting, green interventions, and maintenance, collaborated with the school in planting trees and herbs in the neighbouring park. Additionally, they provided an area within the park to be used as a school garden.

Research and Scientific Organisations: Following the Municipality's initial awareness and engagement actions, teachers from the school participated in the visionary workshop regarding the schools as NBS EduWORLD Living Labs, organised by Ellinogermaniki Agogi's Research & Development department. Additionally, in the framework of its collaboration with the Hellenic Society for the Protection of Nature (HSPN), and its participation in the educational programme of the Foundation for Environmental Education (FEE) 'Learning about Ecosystems and Forests' as well as the 'Global Action Days' campaign, the school incorporated actions in the initiative.

Local Community: Local media covered and informed about the actions.

The **Evangeliki Model Upper Secondary School of Smyrna**'s (Annex 1) initial plan was to revitalise the schoolyard with plants and trees. The plan was unexpectedly thwarted by a

rodent infestation, shifting the focus of municipal services to decontamination and public health.

Actions towards the openness of the school and connections with the community

Local Authorities: Until the rodent infestation, the Municipality of Nea Smyrni had responded positively to the school's NBS vision, led by its vice principal's belief in innovation and sustainability. The municipality had committed to contributing with agronomists and technical assistance for tree planting and yard revitalization and had participated in the co-design workshop with teachers, students, the Parents Association, and external professionals.

External Professionals participated in the co-design workshop, sharing knowledge and sparking inspiration, such as an associate professor at the Agricultural University of Athens and an architect, specialised in urban planning.

Parent Association: The Parents' Association is very active and supportive in every aspect of the school's life. In this context, they supported the NBS EduWORLD initiative from the beginning by contributing to the co-design workshops, contacting external professionals to get technical and financial offers, as well as providing their professional expertise where related. They were also willing to cover any costs.

Research and Scientific Organisations: Following the teachers' participation in the visionary workshop regarding the schools as NBS EduWORLD Living Labs, organised by Ellinogermaniki Agogi's Research & Development department, the Vice Principal attended the NBS EduWORLD's International Professional Development Course 2024 to develop the school's action plan for the academic year 2024-2025.

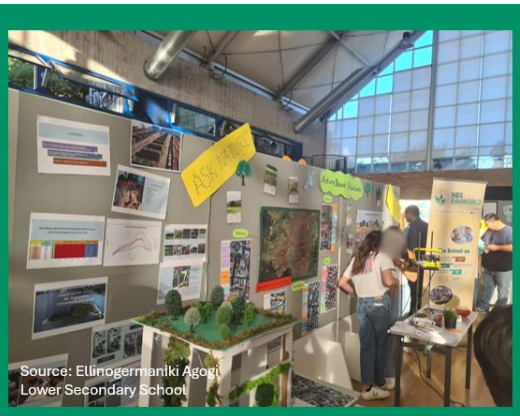
Ellinogermaniki Agogi (Annex 1) has a long tradition in actions towards the openness of the school and connections with the community, leading flagship initiatives like the OSOS[11]. and SALL[12] projects. It also has a long tradition in initiatives related to environmental education and sustainability. In the framework of NBS EduWORLD, the school experimented with new activities and projects, introducing innovative initiatives related to NBS at all levels, from the primary to upper secondary.

Actions towards the openness of the school and connections with the community

Having already established collaborations in working together and exchanging knowledge and ideas with external professionals, parents, and Research and Scientific Organisations, new actions towards the openness of the school and connections with the community regarding NBS were:

- The participation of the **Lower Secondary School** students of the 1st grade in the Green School Athens Hackathon organised by the **Municipality of Athens**, presenting their work on NBS for addressing the heat island effect in neighbourhoods and schools of Athens and building climate resilience based on scientific research. Alongside the 3rd prize, the students will have the opportunity to present their ideas in subsequent actions of the Municipality. The Municipality aims to pilot their ideas in schools and neighbourhoods of Athens. This win, beyond the joy it brought to students and teachers, was a strong demonstration and lesson for the whole school community of what the sense of openness within a living lab can achieve, influencing even policy plans or decisions.
- The presentation of the study on NBS for addressing the heat island effect in neighbourhoods and schools of Athens from the **Lower Secondary School** students in a big school event with more than 600 participants, parents, professionals, and the local community. Again, in this event, students had the opportunity to present and discuss their findings, but also to receive feedback from professionals working in the field.
- The organisation of the **IDEA Student Conference** from the **Upper Secondary School**, aiming to simulate a scientific conference and encourage students in scientific research. NBS was among the conference topics, and they were showcased through presentations and posters. The Conference consisted of a total of 12 sessions, 95 oral presentations, 96 posters, and 12 distinguished members of the scientific and academic community of Greece participating in the scientific committee, thus providing a platform for discussion and exchange on NBS.
- The participation of the **Upper Secondary School** students in the Junior Achievement (JA) Greece National Entrepreneurship Competition. JA focuses on introducing students from school age to the basic concepts of entrepreneurship, preparing them for their entry into the global business and economic areas. The students presented and took feedback from members of the Greek business community on the developed software Minimile, for optimising the school's bus routes, inspired by nature.

[11] https://cordis.europa.eu/article/id/421969-open-schools-initiative-pushes-for-inclusive-and-innovative-societies
[12] https://www.schoolsaslivinglabs.eu/



The students present their study on the Heat Island Effect and propose NBS to a school event targeting the parents and the local community.

The principal, the vice principal, and representatives from the students and teachers receive their award from the Mayor of Athens.

The students present their study on the Heat Island Effect and propose NBS to address it to the Mayor.

The students present the developed software Minimile, inspired by nature, to the IDEA Student Conference and the Junior Achievement Greece National Entrepreneurship Competition.

3.2 Reimagine School's Infrastructure

Available literature recognises that climate change can disrupt children's learning and/or lead to lower academic performance, both directly through damage to infrastructure or injuries/loss of life, and indirectly by threatening livelihood, food, health, and water security (UNICEF, 2019; IDMC, 2021). In addition, there is evidence that shows that rising temperatures and worsening air quality are severely impacting children's health and well-being (Will M. and Lieberman M, 2023).

Both new and existing school infrastructure should integrate climate change adaptation and sustainability considerations into planning, design, construction, and maintenance, ensuring a safe and healthy learning environment for students while minimizing the environmental footprint of infrastructure. Schools should be designed to withstand and adapt to climate-related shocks, such as building green infrastructure with sustainable materials, producing their own electricity, and including space for growing fruits and vegetables (Global Centre on Adaptation, 2022).

Often the strongest infrastructure in a community, school buildings commonly serve as shelters immediately following, and sometimes long after, disasters. Schools should only be used as temporary shelters where there are no suitable alternatives (GADRRRES). Prior identification of non-school locations for shelters increases the likelihood that schools remain solely as educational institutions (UNICEF, 2008). In hazard-prone areas where schools have been identified as the only possible location for shelters, they should be designed, built, or retrofitted for both educational and shelter functions, considering the emergency profile of a given location and the minimum structural performance standards for immediate occupancy (UNICEF, 2009; GADRRRES).

Therefore, school and community stakeholders should play an active role in making decisions about and maintaining the school infrastructure to ensure it becomes safer and greener. Schools should serve as community hubs in the enhancement of local safety and resilience by promoting environmentally sustainable practices in communities, drawing community members into the climate change, disaster risk management, and environmental conservation initiatives of the school, and tapping into their wealth of knowledge.

The potential opportunities linking NBS to the physical and technical infrastructure and daily operations of the school are many and include the transformation of the **school building and the schoolyards to a sustainable, inclusive, and beautiful learning space, following the New European Bauhaus principles**[13] to teach different concepts.

A **Nature-based Infrastructure** (NbI) provides both human benefits and biodiversity benefits (IUCN, 2020; Seddon et al, 2021). The benefits for biodiversity should be considered a foundational property of NbI, and not just an additional benefit. This is particularly important to maximise the resilience of natural ecosystems and the long-term success of NbI in the face of temperature increase and climate change impacts (UNEP, 2023).

NbI can provide various services that underpin positive educational outcomes (UNEP, 2023), such as the development of creativity, increased attention span, increased cognitive

[13] https://new-european-bauhaus.europa.eu/index_en

functioning, and cognitive development (Stenfors, 2019; Bratman, 2015). Studies report that NbI can lead to improved progress in working memory and reduced inattentiveness (Dadvand et al, 2015). For example, in the Netherlands, children in classrooms with green walls scored better on a test for selective attention than those in classrooms without green walls (van den Berg et al, 2016). Engagement with green space is linked to improved behavioural development, reduced emotional symptoms and peer relationship problems, and reduced rate of Attention Deficit Hyperactivity Disorder (ADHD) in children (Amoly et al, 2014). Educational gardens can provide opportunities for disabled and special needs students to connect with nature through sensory stimulation and undertake interactive learning (Hussein, 2010; Hussein, 2012). NbI can also facilitate student learning about nature and the environment, increase connections to nature, and boost pro-environmental behaviours, which is of high importance given the current climate and biodiversity crisis (Kuo et al, 2019).

3.2.1 See infrastructure as a field of learning

To transform a school into an NBS Living Lab, considering the school's infrastructure as a field of learning is essential. In this sense, schools can promote deep experiential learning in sustainability, serving dual purposes: to deliver real ecosystem functions and to serve as sites for inquiry-based (science) education. The application of inquiry as a didactic strategy has been extensively validated in the educational field, as it enables active knowledge construction and fosters scientific research skills in real-world scenarios (Creswell and Plano Clark, 2017).

For doing so, schools should:

- Be inspired and informed on how the school's infrastructure can act as additional classrooms, extending the learning beyond the traditional classrooms.
- Embed in the school life and curriculum initiatives and policies that promote or establish interventions in the schools towards sustainability and NbI.
- Follow the open schooling approach and living lab methodology, as described previously, to support new NBS interventions.
- Find ways to link existing NbI and sustainability to their school's strategy and curriculum to support the learning and teaching process, or experiment with new methods.

3.2.2 Make the most of what you have

It is an indisputable fact that there is a pressing need to adapt schools, as most of them have not evolved to accommodate the changing needs of learners or communities (Sanoff, 2021). Many learning environments are poorly equipped for 21st-century learning, which is increasingly learner-centred and diverse regarding the ways students learn (Blyth et al, 2019). School buildings and grounds often need basic renovation to improve hygiene, health, and comfort accessibility, as well as investment to reduce climate emissions (Blyth et al, 2019). The EU has committed to climate change targets and a green transition, and renovations in schools' infrastructure have started through EU or National funding.

Schools could contribute to the achievement and sustainability of these high-level commitments and efforts by experimenting with infrastructure within their schools as NBS

Living Labs to provide guidelines to support this aspect of the transition and benefit from targeted funded interventions tailored to their needs.

This applies to both schools that do not have NbI and to schools that already do. The first could benefit from the open schooling approach and living lab methodology, as mentioned earlier, to make NBS interventions in the infrastructure, and the second can explore the integration of existing NbI into the educational process and the school's life, exploring other pillars of the WSA.

For example, an already in place school garden can be a testbed for doing math or science, a "new teachers" training area, or an area for bringing together the school and community members to interact. Or even the place where the digital and green transitions will be bridged through school education[14]. Using technology, schools can facilitate hands-on experiences, such as digitally monitoring the garden (soil moisture and pH, temperature, humidity, and light levels) with a combination of hardware sensors, mobile apps, and potentially cloud-based platforms.

3.2.3 Explore alternative uses of spaces

An important part of a school's infrastructure, usually forgotten when talking about sustainability and adaptation to climate change (intense heat waves, floods) in schools, is the sports facilities, both outdoors and indoors.

Sports facilities use a lot of space, are cost-intensive, and require special building materials, especially for the playing surfaces. In addition, operators of outdoor sports facilities play a singular role: Municipalities often build and maintain sports facilities for clubs, schools, and sports practitioners, but are not the end users themselves. Furthermore, changes in user behaviour and requirements can be observed (Wetterich et al, 2009), with the popularity of trend sports such as parkour or calisthenics greatly increasing. In addition, sports events can negatively impact biodiversity through large numbers of spectators, who increase noise, vibration, and lighting (Wheeler et al, 2020). What is urgently needed is consideration for the sustainable development of sports facilities that promotes a lasting consensus between the stakeholders, the costs, and the environment (Katthage, Jutta et al, 2017).

NBS can trigger schools to rethink and reframe sport facilities to contribute to the restoration and enhancement of biodiversity, embody sustainability, and shape the experiences of their users. Some considerations include the incorporation of green roofs and walls, use of water collection features, pollinator and rain gardens, sustainable drainage systems (SuDs), and parkour hills. The use of sound barriers, reduced lighting, or blue/green lighting around features intended to attract or support wildlife are additional potential interventions, alongside the installation of bird-safe windows or bird boxes for enhancing biodiversity.

3.2.4 Inspiring Stories of Implementation

The **9th Primary School of Rethymno** (Annex 1) is an established Living Lab developed around the school garden. Since 2006, a neglected area of the school has been transformed into a school garden, which functions as a natural extension of the classrooms and is an

[14] Stefania Giannini, 2024, Bridging the green and digital transitions through education. © UNESCO 2024

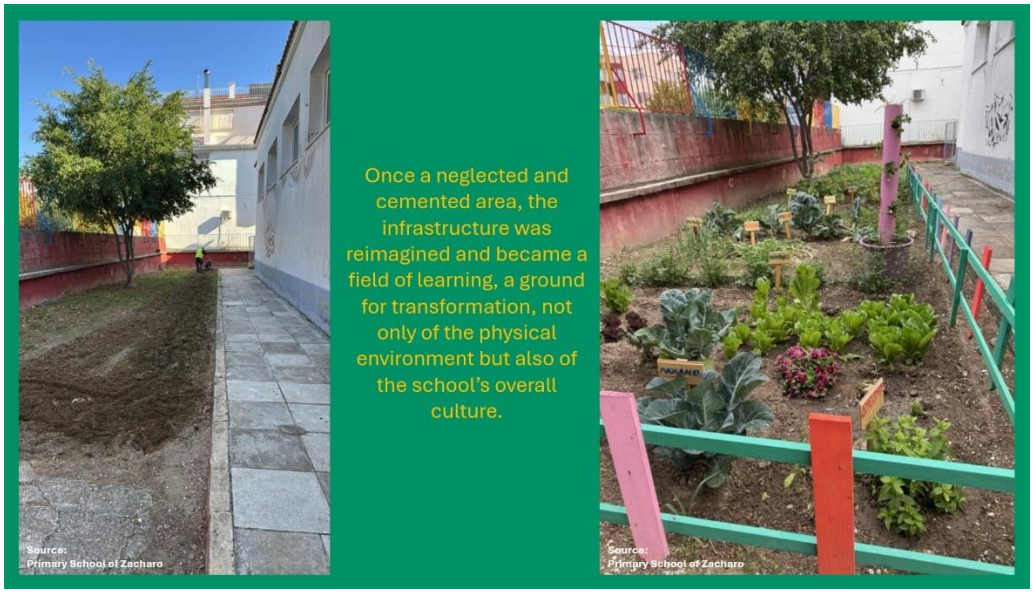
integral part of the school community. Following an open schooling process and the living lab methodology, the principal of the school, a former teacher and the person responsible for the physics lab, has, over the years, involved various members of the local community, students' parents, professionals, research organisations, academics, and others in the initiative. Nowadays, the school explores the existing NbI as a testbed for experimenting with new teaching methods, such as using concept cartoons for the development of (scientific) arguments.

Additionally, the school's experience contributed to the Greek Ministry of Education's initiative '**School gardens: with critical thinking and vision, we collaborate, enjoy, and create**' with a total budget of 1,998,538.00€. The Ministry will supply 4.384 primary schools participating in the programme, in the school year 2025-26, with plant beds, soil, gardening tools, greenhouses, sprinklers, and seed sets for the first crops, to create the needed infrastructure for growing vegetable gardens. The school's Principal consulted the Ministry on both technical and educational aspects of the initiative[15] and will contribute to the development of implementation guidelines[16].

The **Primary School of Zacharo** (Annex 1) transformed into an impressive NBS Living Lab, starting, however, from a lower level of expertise and innovation. The school community was inspired and informed – by following the NBS EduWORLD Academy – how the school's infrastructure could become an additional classroom, extending learning beyond the traditional one. Then, they embed the creation of the garden into the school life and curriculum, following the open schooling approach and living lab methodology to support the intervention (§3.1.4).

[15] https://www.esos.gr/sites/default/files/articles-2023/%CE%A1%CE%9A%CE%94146%CE%9D%CE%9A%CE%A0%CE%94-%CE%983%CE%95.pdf

[16] https://www.alfavita.gr/ekpaideysi/ypoyrgeio-paideias/486640_sofia-zaharaki-ayti-einai-i-omada-ergasias-gia-programma



The same applies to the **6th Lower Secondary School of Volos** (Annex 1), which similarly transformed into an NBS Living Lab, starting from a lower level of expertise and innovation. However, the long experience and vision of the principal, who had recently joined, played an important role. Again, the school community was inspired and informed, embedding, afterwards, the creation of the garden into the school life and curriculum by following the open schooling approach and living lab methodology to support the intervention (§3.1.4) and the inclusiveness of the school, especially considering the 36 Roma students.

Ellinogermaniki Agogi (Annex 1) explored both alternative uses of spaces and the NbI as a field of learning. NBS gave the trigger to rethink and reconstruct the primary school's sports area, as well as to construct a new basketball area in the secondary school.

In the first case, various hills and permeable pavements were created alongside tree planting, bringing a sense of nature to the traditional sports area of the school, providing shade and an

area for walking for students who don't play basketball/volleyball, and improving their sense of comfort during breaks.

The construction of a new schoolyard for the lower and upper secondary schools was conducted again under the lens of NBS. Various Mediterranean plants and trees were planted, permeable pavements were constructed, and three small-scale basketball courts were built within the area, bringing a sense of doing sports in nature. Furthermore, bird boxes and pollinator-friendly species were incorporated.

The new NbI, alongside the already existing, such as the micro forest primary schoolyard, were used to create a digital educational trail for primary school students to explore the NBS and the biodiversity of the school[17].

3.3 Build a Continuous Learning Pathway through the Curriculum

As described earlier, becoming an NBS Living Lab, needs to be seen through the lens of an Open School, an innovative ecosystem, which acts as a shared site of learning for which leaders, teachers, students, and the local community share responsibility. **To move from the "division of labour" to "shared responsibility", everyone needs to have the skills, knowledge, and the desire to contribute**. Thus, schools are no longer viewed as closed entities in themselves, but rather as part of the larger ecosystem within which they operate.

These schools aspire to operate with a curriculum that recognises the need for interdependence and broadens the goals of education to include "education for citizenship"[18]**.** Such a curriculum recognises the differences between individual students and

[17] https://kool.avastusrada.ee/

[18] https://www.oecd.org/content/dam/oecd/en/about/projects/edu/education-2040/publications/Project%20background%20E2030%20Introduction_FINAL_rev.pdf

acknowledges that each student has different prior knowledge and skills, as well as different attitudes and values, and, therefore, may learn differently. Thus, curricula have to be dynamic rather than static. They have to allow for non-linear learning paths rather than expect all students to follow linear progressions along a single, standardised path. They have to be more flexible and personalised to ensure that each student's unique talents are developed so that all students can realise their full potential.

Likewise, whereas student learning outcomes and academic achievements traditionally define the effectiveness and the quality of their school experience, student well-being and students' learning experiences – the quality of "learning processes" – have to be raised in value and expanded to focus beyond "outcomes".

Thus, approaches to curriculum design and learning progression have to shift from a "static, linear learning-progression model" to a "non-linear, dynamic model", which recognises that each student has their own learning path and is equipped with different prior knowledge, skills, and attitudes when they start school.

NBS EduWORLD Living Labs are built on the above by developing **competence-based curricula** that integrate knowledge, skills, attitudes, and values. They are concept-driven and skill-oriented and rooted in real-world experience and relevance. They ensure that subject knowledge is not static but brought to life through the mobilisation of human capacities to solve complex problems and co-create more just, sustainable futures[19].

These competence-based curricula cannot be developed by sitting in the classroom and learning alone, but require active, meaningful engagement with the world. Students learn to be equipped with these foundations and competences through the anticipation-action-reflection cycle, through **continuous learning pathways** during their entire school life, supported by families, educators, and communities.

3.3.1 Start with the big picture

For building a competence-based curriculum, schools should focus on:

- Embed NBS and sustainability throughout the curriculum in every subject and discipline. An integrated, cross-curricular, and interdisciplinary approach is proposed.
- Consider that curriculum changes refer to every level, from kindergarten to upper secondary education. LfS should be promoted throughout the lifecycle and ensure that individuals continue to develop pro-environmental actions throughout their lives.
- Making use of any related initiative at local, National, or European level.
- Align curriculum changes with changes in pedagogies and teaching practices.
- Align curriculum changes with changes in teachers' and school heads' professional development.

[19] OECD Teaching Compass for 2030

- Integrate curriculum changes as part of a larger system of change management in the school to support school autonomy.

The competence-based curricula developed by NBS EduWORLD Living Labs are grounded in the GreenComp[20], as the framework sees education and sustainability connected at all levels within disciplines and subjects, through the competences embedded within the curriculum. It recognises that all sustainability dimensions (environmental, social, cultural, and economic) are interlinked (Figure 8[21]).

Figure 8: The main dimensions of sustainability (OECD 2022)

The curriculum should integrate approaches that prioritise hands-on activities, real-world problem solving, and individualised learning paths, fostering autonomy, creativity, and critical thinking. Such a curriculum also requires a re-evaluation of teaching methods to ensure they are flexible and responsive to students' diverse learning styles and paces (see Section 3.4).

3.3.2 Innovate in instructional design

Instructional design is the design, development, and delivery of learning experiences. When it comes to designing a learning experience, teachers must consider three main components to ensure effective learning: learning objectives, learning activities, and assessments.

Driven by an NBS competence-based curriculum, the instructional design:

- Defines and sets boundaries on what learners should know or be able to do at the end of the course that they could not do before.
- Describes the expected objective/outcome in terms of demonstrable competences that will be acquired as a result of the instruction provided.
- Plans and develops learning activities informed by the defined learning objectives.
- Finds ways to check that the learning objective was met and the cognitive “action and reflection” processes needed for learning to take place effectively were followed.

A common observed practice is to develop activities without first defining the learning objectives. Although the outcomes may be valuable and demonstrate satisfaction or competence acquisition, this usually leads to the exploration and assessment of specific competences, those that are “easier’ to observe”. Many school activities and projects promote nature and acting for sustainability (Figure 9), but how many develop substantial systems and critical thinking?

[20] https://joint-research-centre.ec.europa.eu/greencomp-european-sustainability-competence-framework_en
[21] Young People’s Environmental Sustainability Competence, OECD 2022

Figure 9: GreenComp Competence Areas

For a school as NBS Living Lab, it is crucial to start by identifying and setting very targeted and specific learning objectives, linked to the GreenComp Framework and ideally combined with other competences frameworks, going beyond the ordinary paths of instructional design and thus innovating with NBS.

3.3.3 Inspiring Stories of Implementation

Ellinogermaniki Agogi (Annex 1) built a competence-based curriculum (Figures 10, 11, 12) for exploring NBS and sustainability, following the initial plan that had been described in deliverable D6.1: Scenarios of Plausible Futures for NBS in Education[22], making the necessary changes and corrections when needed, after the reflection workshops that the teachers and school heads had. For doing this, the school:

- Embedded projects related to NBS and sustainability of primary and secondary schools in different subjects and disciplines, making use in some cases, like in the secondary level, of the "Skills Lab"[23] hours provided in the curriculum by the Greek Ministry of Education. Furthermore, the reform by the Greek Ministry of Education of the Greek Curriculum with the introduction of the "Active Citizenship" programme linked to the 17 SDGs is believed to additionally support the actions.
- Aligned curriculum changes with changes in pedagogies and teaching practices and provided teachers and school heads with sufficient professional development support.
- Explored the development of additional GreenComp competences, such as "envisioning sustainable futures" and "exploratory and systems thinking", beyond the "usually reported" ones such as "promoting nature".

[22] https://nbseduworld.eu/fileadmin/user_upload/Resources/NBS_EduWORLD_D6.1_Scenarios-Plausible-Futures-NBS-Education.pdf
[23] https://eurydice.eacea.ec.europa.eu/news/greece-21st-century-skills-labs-ergastiria-dexiotiton

Figure 10: The NBS curriculum for primary school

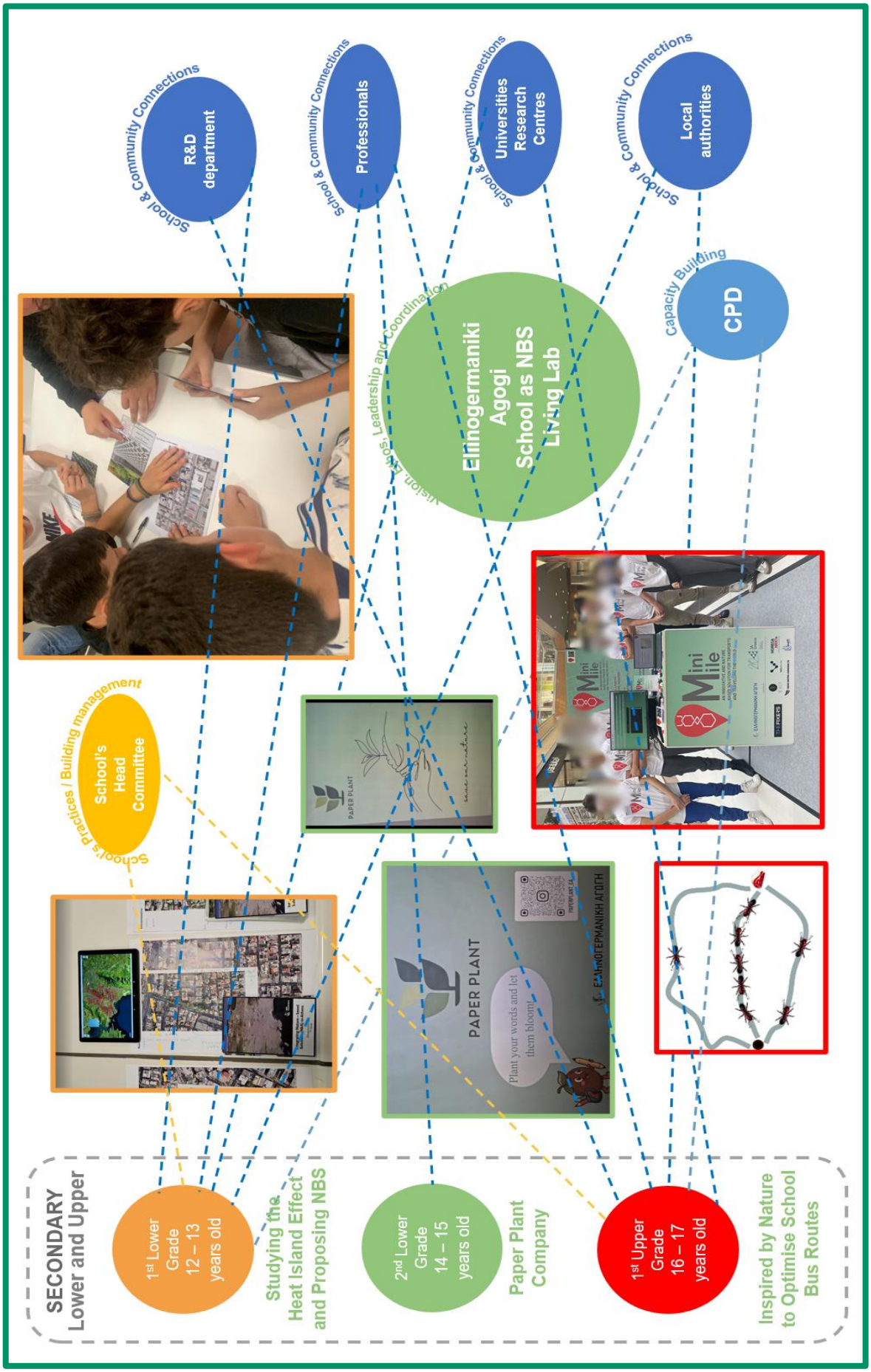


Figure 11: The NBS curriculum for secondary school

Figure 12: The NBS curriculum for primary school (English Lessons)

3.4 Improve Teaching and Learning

Curriculum and instructional design are only one aspect of curriculum reform. Whether such efforts make a difference to classroom teaching and learning depends on successful curriculum realisation.

Schools can influence the likelihood that students will develop environmental sustainability competences through two main channels: a) socialisation and b) curricular content and instructional practices. The second channel through which schools could shape environmental sustainability competence is curricular and extracurricular activities organised in schools, as well as **the pedagogical approaches used by the teaching staff**. Previous studies suggest that the use by teachers of active learning techniques and the adoption of constructivism pedagogies may enhance scientific understanding and, therefore, improve a key dimension characterising environmental sustainability competence[24].

Moreover, student-centred and collaborative teaching methods can foster students to critically elaborate on environmental problems and increase their awareness of the topic (McKown and Hopkins, 2007; Tilbury and Wortman, 2005). In the same way, by helping students to enjoy science and increase their curiosity about the topic, extracurricular activities may have a positive effect on environmental attitudes (Littledyke, 2008; Fröhlich, Sellmann, and Bogner, 2013).

The literature has generally conferred a relevant role to teaching practices in influencing students' performance (Isac et al, 2015; Da Costa and Araújo, 2018). Adaptive teaching (Gomendio, 2017) and continuous feedback to students (Hattie and Timperley, 2007; Lipko-Speed, Dunlosky, and Rawson, 2014) can stimulate academic achievement (Brussino, 2021). However, besides students' results at school, teaching methods also appear to foster their environmental awareness (McKown and Hopkins, 2007; Tilbury and Wortman, 2005). Indeed, specific teaching approaches may foster critical understanding of scientific and environmental problems (Littledyke, 2008; McKown and Hopkins, 2007).

In this sense, in an NBS Living Lab:

- Teachers focus on problems and issues - the subject matter is functional and relevant for the students' understanding of the complexity of the issues.
- The theories and concepts from the academic disciplines are utilised to rationalise often naive and uncritical experiential knowledge.
- Teachers explore ideas and perspectives to reactivate and innovate teaching and learning in traditional subject matters.
- Teachers' focus is on students' capacities needed for meaningful participation and co-operation, e.g., listening, expressing points of view, taking responsibility, and showing solidarity.

[24] Young People's Environmental Sustainability Competence, OECD 2022

- Teachers give space for students to take part in the decision-making process appropriate to the students' age and abilities.
- The teaching focus lies on authentic action strategies, on action possibilities, and experience from real actions.
- Teachers listen to and value the concerns, experiences, ideas, and expectations of the students, and their plans are flexible and open to change.
- Teachers facilitate students' participation and provide context for the development of students' own learning, ideas, and perspectives.
- Teachers accept the challenge of not imposing their own values and opinions, allowing students to hold their own positions.
- Teachers encourage cooperative learning and experiential learning.
- Teachers consider the value of practical activities by linking them to students' concept development and theory construction.
- Students participate in decisions on action to influence the problem, and they are learning from reflecting on their experiences.
- Students' involvement in action is accompanied by reflections on local and global effects, comparing risks and possibilities of alternative decisions.
- Students are encouraged to look at things from different perspectives and to develop empathy by identifying themselves with others.
- Students are encouraged to give arguments for different positions.
- Students are encouraged to look for examples of what is (or was) useful and fruitful in other situations, to imagine new possibilities and alternative actions.
- Students work on constructing their understanding of the problem, looking for different interests and different points of view, before trying to find a solution.
- Students can appreciate and confront diversity – biological, social, cultural – and look at this as "opportunities" for broadening options for change.
- Students are encouraged to listen to their emotions and to use them as a way to reach a deeper understanding of problems and situations.
- Students and teachers accept uncertainty as part of daily life and prepare themselves "to expect the unexpected and to deal with it", being aware of the importance of the precautionary principle.
- Students work with visions and scenarios, seeking alternative ways of development and changes for the future, and establishing criteria for choice (Breiting et al, 2005).

3.4.1 Rethink education in the context of societal challenges

A school as NBS Living Lab should rethink education in the context of societal challenges, considering that NBS provide integrated, multifunctional solutions to these societal challenges[25].

Taking into consideration that NBS education within the NBS Living Labs is an overarching goal, teaching is the means to achieve that goal. An effective teaching for NBS education must include active and student-centred approaches such as place- and challenge-based, experiential, and inquiry-based. In this way, students are at the centre of learning, which is the outcome of the interaction between education and teaching. This gives them a greater sense of learning ownership and sustained interest beyond the classroom.

Place-based education (PBE) refers to "a pedagogical approach that emphasises the connection between a learning process and the physical place in which teachers and students are located" (Yemini, Engel and Ben Simon, 2023). It has become an umbrella term for any educational approach that is locally driven, community-based, or ecologically focused (Yemini, Engel, and Ben Simon, 2023). PBE connects to a variety of educational practices with a long and rich history, such as outdoor, community- and service-learning, in the sense that they all seek to engage students cognitively, emotionally, and physically in their learning while fostering a sense of connection between them and their surroundings (Elfer, 2011)[26].

Challenge-Based Learning[27] (CBL) provides an efficient and effective framework for learning while solving real-world challenges. The framework is collaborative and hands-on, asking all participants (students, teachers, families, and community members) to identify big ideas, ask thoughtful questions, research and explore solutions, and thus solve challenges, gain in-depth subject-area knowledge, and share their thoughts with the world. CBL builds on the foundation of **experiential learning** and leans heavily on the wisdom of a long history of progressive ideas.

CBL typically includes three phases, which can be followed by those who teach[28].

- Engage – Students connect with the topic and identify a relevant challenge.
- Investigate – Students gather information, ask questions, and analyse the problem.
- Act – Students implement their solutions and reflect on their impact.

Additionally, **impactful NBS education requires being anchored in basic scientific literacy**. Scientific knowledge and skills offer a foundation for people to understand the complexity of Earth's systems and their interactions with human systems, to critically evaluate different information sources about socio-environmental challenges and solutions, and to make informed choices in their personal, civic, political and professional lives (Young et al, 2006; Monroe et al, 2019).

[25] https://op.europa.eu/en/publication-detail/-/publication/aeb73167-0acc-11ec-adb1-01aa75ed71a1/language-en
[26] https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/02/rethinking-education-in-the-context-of-climate-change_61bfd890/f14c8a81-en.pdf
[27] https://www.challengebasedlearning.org/
[28] https://www.utwente.nl/en/cbl/documents/dcu-futures-cbl-implementation-guide-for-those-who-teach.pdf

Inquiry-Based Science Education (IBSE) has been proposed as a framework for conceptualising the priorities and values of authentic science teaching and learning. The main features of this framework include active pupil engagement in the learning process with emphasis on supporting knowledge claims with observations, experiences or complementary sources of credible evidence; tackling of authentic and problem-based learning activities; consistent practice and development of the skills of systematic observation, questioning, planning and recording with a purpose to obtain credible evidence; committed participation in collaborative group work, peer interaction, construction of discursive argumentation and communication with others as the main process of learning; and the development of autonomy and self-regulation through experience as important goals of learning (Constantinou et al, 2018).

Inquiry-based learning is an educational strategy in which students follow methods and practices similar to those of professional scientists to construct knowledge (Keselman, 2003), engaging them in an authentic scientific discovery process. From a pedagogical perspective, the complex scientific process is divided into smaller, logically connected units that guide students and draw attention to important features of scientific thinking. These individual units are called inquiry phases, and their set of connections forms an inquiry cycle (Figure 13, Pedaste et al, 2015).

Often, it is viewed as an approach to solving problems and involves the application of several problem-solving skills (Pedaste and Sarapuu, 2006). Inquiry-based learning emphasizes active participation and learners' responsibility for discovering knowledge that is new to the learner (de Jong and van Joolingen, 1998).

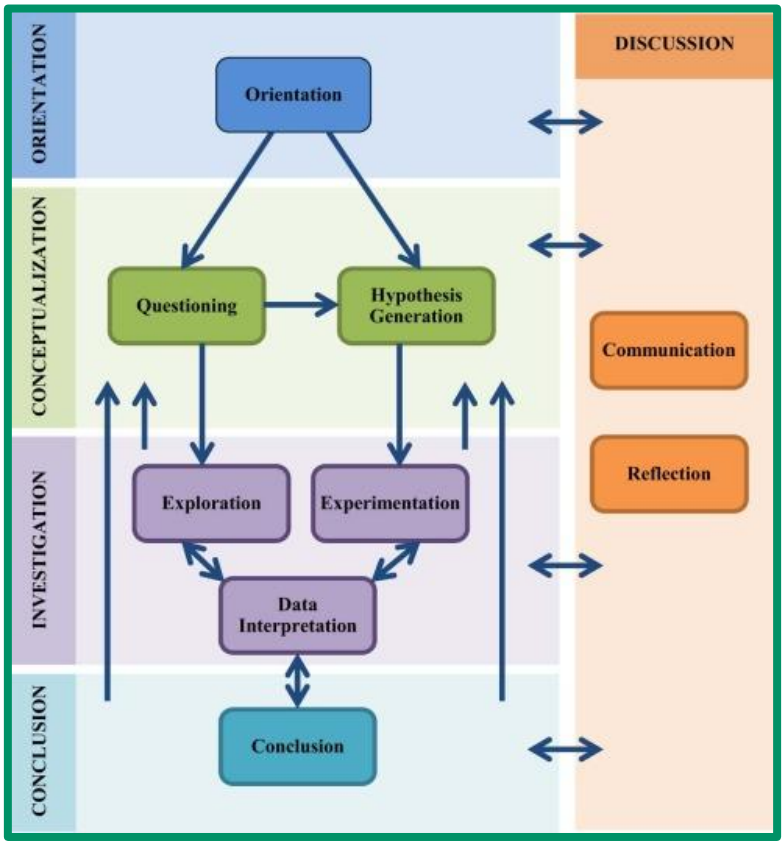


Figure 13: Phases and subphases of inquiry-based learning and their relations (Pedaste et al, 2015)

3.4.2 Bridge NBS education with digital education

> "Education is the key to bringing the digital transition into better harmony and confluence with the green transition. Education can forge a new kind of citizenship – one that is committed to harnessing the power of digital technology to activate and drive the green transition."[29]
>
> Stefania Giannini,
> UNESCO. Assistant Director-General for Education, 2018

"Is there a place for NBS education in the hi-tech digital world that we live in?".
This was a question that was frequently raised during the lifecycle of the NBS Living Labs, putting limitations on ideas.
The answer came from the "living labs" participants themselves, thus reminding everyone that nothing can stand in the way of the creativity that education can bring, especially in the framework of a living lab.

Therefore, the NBS Living Labs became places where digital and green transitions were bridged[29] through the use of digital tools for the development of educational trails for exploring nature and discovering NBS, satellite imagery, and GIS (Geographic Information System) technology to map areas suffering from the Heat Island Effect and proposing NBS, or Virtual Reality for envisioning a future world without pollinators.

The ability of digital tools to allow users to envision potential futures, using Augmented or Virtual Reality, is principally a key opportunity, as these skills are essential for sustainability competences. For instance, digital tools could allow people to visit places that are inaccessible, far away, no longer exist, or never even existed. By enabling users to visualise something that would otherwise be invisible to them, digital technologies make it possible to engage with the environmental issues in a more engaging way, which is especially crucial when those users are youngsters. In short, the promotion of digital literacy by using tools such as Augmented/Virtual Reality could represent an efficient way to promote environmental literacy (Fauville, Queiroz and Bailenson, 2020)[30].

In addition, digital technologies are key to monitoring, with precision, the state of the environment and assessing the impact of policies and interventions with the aim of identifying good practices and bringing such practices to scale. For example, satellites allow for real-time collection of data on greenhouse gas emissions and deforestation, or the warming of cities. To some extent, digitalisation may accelerate the transition towards a greener economy, and digital competences could play a prominent role for the green ones (Cecere et al, 2014)[30].

As the climatologist, Hans Joachim Schellnhuber[31] highlighted at the New European Bauhaus festival: "If we want to reach climate resilience, no-tech needs to meet high-tech. Ingenuity needs to meet Evolution. The newest knowledge must be linked with no-tech, and this is nature."

[29] Stefania Giannini, 2024, Bridging the green and digital transitions through education. © UNESCO 2024
[30] The environmental sustainability competence toolbox, OECD 2022
[31] https://new-european-bauhaus.europa.eu/events/festival/forum/speakers/hans-joachim-schellnhuber_en

3.4.3 Inspiring Stories of Implementation

Ellinogermaniki Agogi's Primary School English Department (Annex 1) embraced NBS with enthusiasm. Following many years of approaches, such as storytelling, hands-on, and art & craft, they were interested in combining English language learning with environmental education and LfS, offering students context to use English for authentic communication and awareness-raising. In the framework of NBS EduWORLD, they integrate NBS into the curriculum (Figure 12), linking them to relevant sections of the textbooks in 5th (10-11 years old) and 6th (11-12 years old) grades. The "**Bee Kind**" project focused on the vital role of pollinators, biodiversity, and sustainable agriculture, while the "**Save our Oceans**" project explored why oceans are essential to life on Earth, the challenges they face, and how NBS address them.

*Key phases of the "**Bee Kind**" project implementation:*

Envisioning a world without pollinators: Starting with an immersive experience, students made a virtual visit to the EU Pollinator Park[32] to discover what our world would look like without pollinating insects (§3.4.2). They were introduced to pollinators, their ecological value, and the urgent threats they face. Pre- and post-visit activities were carried out in English, allowing students to enrich their vocabulary while discussing NBS.

NBS through action: Students constructed bee hotels and placed them in the school garden. They also set up watering pots and monitored pollinator visits, taking notes in English.

NBS through storytelling: The exploration continued through storytelling. Students wrote original stories, comics, and dialogues about bees and eco-friendly habits, integrating grammar, structure, and creativity. They also learned about the benefits of local honey, the importance of supporting local farmers, and how our daily choices affect biodiversity.

Exchange with a school in Ireland: Students collaborated with Curraghboy National School in Ireland, engaging in an intercultural exchange of experiences and ideas about how young learners can support pollinators in different countries.

Raising awareness across the school and the wider community: Students created posters and a decorated bulletin board, composed and performed an authentic song about bees[33], recorded video messages and dialogues in English, and participated in a school-wide event where parents and local guests visited their eco-exhibition.

*Key phases of the "**Save our Oceans**" project implementation:*

Exploration of oceans and challenges: Through interactive games, engaging videos, and group research, students learned about the critical issue of microplastics and their impact on marine life.

Exploration of NBS: Students studied how NBS, like mussels and oysters, address ocean pollution and presented their findings through posters, infographics, mind maps, presentations, digital stories, comic strips, and models.

[32] https://environment.ec.europa.eu/topics/nature-and-biodiversity/pollinator-park_en
[33] https://www.youtube.com/watch?v=y-WSOHwZIsk

The **Bougas Lower Secondary School** NBS EduWORLD Living Lab (Annex 1) followed the PBE and CBL approaches, targeting a real challenge of the local context: the increasing erosion of the eastern shoreline of Kalamata, a coastal area threatened by changing weather patterns. From the beginning, the goal was not only to inform students about the problem but to empower them to investigate and study the issue, understand its causes, and co-design solutions based on nature.

The COAST PROS project, as it was titled, blended STEM education, environmental literacy, and design thinking. It was implemented as part of the "Skills Lab" hours, which allowed teachers from different disciplines to collaborate and provide time for experimentation. The first task of the team was to choose a name and identity that reflected their purpose. One student, drawing on interest in AI and graphic design, created a logo for the newly formed COAST PROS. This branding helped establish ownership in the work that would follow.

Project's initial objectives:

- Raise environmental awareness among students through authentic, local issues.
- Support understanding and communication of the causes and impacts of climate change, particularly its effects on coastal ecosystems.
- Engage students in fieldwork to observe and document the visible signs of coastal erosion.
- Encourage critical thinking and creativity in generating practical ideas for mitigation and adaptation.
- Design, prototype, and test NBS to address the challenge.

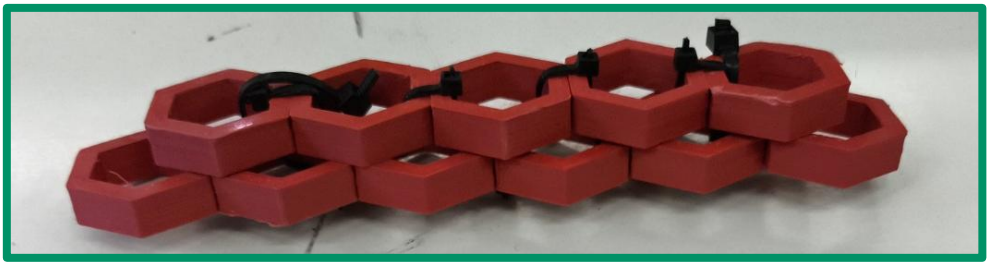
Key phases of the implementation:

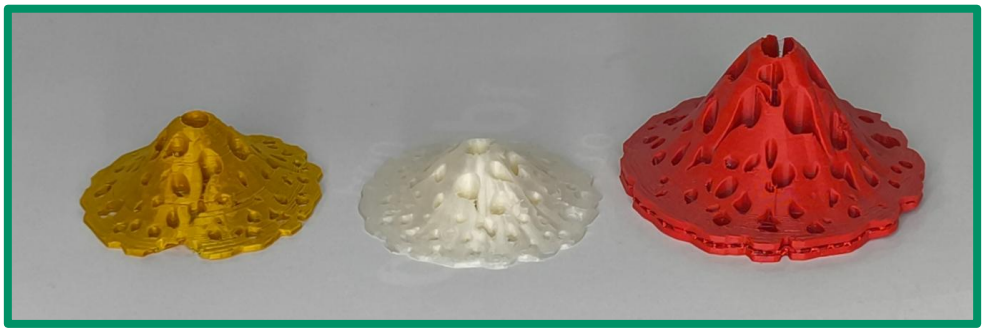
- **Field observations & Data collection**: The students began with on-site investigations along the eastern coast of Kalamata, where erosion has become an urgent issue. They observed how strong seasonal winds, particularly the northwesterly Maistros, intensified wave activity and caused shoreline retreat. Using cameras and notebooks, they recorded the erosion, such as lost beaches, collapsing walls, and makeshift private attempts to hold back the sea. Their observations were supported by real-time meteorological data from the school's weather station, which is linked to the Athens Observatory.
- **Understanding erosion mechanisms**: To better understand how waves interact with coastal formations, students co-designed and built a wave simulation tank using reclaimed materials. With the support of the school's Physics Lab, they engineered a small-scale environment where wave energy could be studied in a controlled setting. A wave generator made by the students, using a small car motor, allowed them to simulate repetitive impacts and observe how different materials and formations resisted erosion.

- **Exploration of NBS to address the challenge**: The team studied many NBS for coastal erosion, such as mangroves, salt marshes, coral and oyster reefs, and dunes, aiming to experiment and test to be able to propose them as solutions.

- **The project at risk**: A critical point was the realisation that none of the NBS studied was appropriate for the local context. Students and teachers struggled to overcome the obstacle while remaining consistent with their initial goals.
- **Inspired by Nature Design**: Watching a documentary on how nature inspired a winning boat design at the America's Cup was the moment the team needed. This sparked their interest in how nature's forms and strategies can be used as an inspiration to solve challenges, and especially in how organisms like birds and bees structure their bodies to deal with force and flow. They ended up with one solution using hexagonal cement units, inspired by honeycomb geometry, to reinforce shorelines. Another solution they found involved 3D-printed artificial reefs, made from cement mixed with crushed shells, also to encourage marine life colonisation.
- **3D Prototyping & Wave Testing**: With support from the school's 3D printing team and STEM teachers, students created several prototypes of hexagonal and reef modules. Initial versions floated, a happy accident that led to deeper discussions about material density. Once corrected, the elements sank and stayed fixed during wave simulations. Students tested multiple configurations (walls, clusters, staggered barriers) to evaluate effectiveness

in dampening wave energy. After trials, they noted how the modules became naturally embedded in the sediment, replicating the self-reinforcing behaviour seen in real coastal systems.





- **Iterative Design & Refinement**: The design process was iterative. Students experimented with different hexagon sizes, fastening techniques (e.g., tire-up instead of bolts), and placement strategies inside the tank. They even contacted companies producing eco-reef elements abroad to get consultation.
- **Presenting the findings and the solution:** In a big school event, open to the local community of Kalamata and covered by the local media[34], students presented their study and findings, proposing the developed solution to parents and representatives of the local authorities.

For **Ellinogermaniki Agogi Primary School** (Annex 1) students (6th grade, 11-12 years old), studying the installation of a wind farm in Greece, considering different criteria, such as wind potential and distance from areas of environmental and archaeological interest, is an established and successful activity.

In the framework of NBS EduWORLD, students went one step further (Figure 10), enriching their study through STEM in three directions: a) exploration on how NBS can enhance biodiversity on the seabed of the offshore wind farm, b) inspiration by forms and mechanisms found in nature, such as the blades of whales or birds, to design wind blades to improve the performance and aerodynamics of wind turbines. The design process evolved from drawing sketches on paper to 3D printing and testing through coding and robotics, c) experimentation with motion sensors, such as Arduino, to shut down wind turbine models to protect birds.

[34] https://www.messinialive.gr/lysi-sti-diavrosi-ton-akton-apo-tous-mathites-ton-ekpaideftirion-mpouga-otan-epistimi-mimeitai-fysi/

Klimatia Kindergarten (Annex 1) is a very small but active and innovative school in a semi-mountain village, having an experienced and motivated expert teacher involved in many programmes and initiatives. In the framework of NBS EduWORLD, the school explored NBS through the exploitation of STEAM Education. Students experimented with digital tools, like Tinkercad[35] to design a composter that the Mayor was then asked to provide. The little students, after identifying the need for a composter for the fruit and vegetable scraps of their school meals as well as for the dry leaves of the schoolyard, digitally designed it, using Tinkercad. The next step was to send a letter to the Mayor asking for the composter. The mayor positively answered their letter, sending the composter.

Ellinogermaniki Agogi Lower Secondary School (Annex 1) students (1st grade, 12-13 years old) studied the Heat Island Effect (HIE) and proposed targeted NBS in areas of Athens with increased heat risk (Figure 11). The school was initially based on IBSE, a key pedagogical pillar on which Ellinogermaniki Agogi has structured numerous educational interventions, to explore the HIE and how NBS can address it. As the study evolved, CBL and PBE, as well as digital technologies, were followed and used, offering students and teachers a variety of practices, experiences, and opportunities for competence development.

Key phases of the implementation:

Students initially explored the global and local contexts of global warming and environmental challenges. Using satellite imagery and GIS technology (digital map), they investigated HIE and were introduced to the Heat Risk Index and the parameters that comprise it.

[35] https://www.tinkercad.com/

Guided by inquiry-based worksheets, they conducted two experimental investigations. In the first experiment (indoor), students worked with various materials, including sand, a wet sponge, a dry sponge, water, wood, soil, and gravel. By subjecting them to a controlled heat source, they recorded the temperature changes over time and subsequently measured the cooling rates for each material once the heat source was removed. This experiment was designed to facilitate an analysis of the thermal properties of different materials.

In the second experiment (outdoor), students used maps of the school premises and UV thermometers to measure the ground temperatures of diverse surfaces, such as concrete, soil, grass, permeable surfaces, gardens, and shaded areas, within the school yard. After this practical exercise, the students discern which materials and surfaces contribute most effectively to reducing ground temperatures and mitigating the Urban Heat Island effect.

After discussing their conclusions on the significant difference, the materials can have on ground temperatures, each team chose a high-risk neighbourhood from the digital map to work on.

Based on the research findings of ”A Cost-Benefit Analysis of Nature-Based Solutions for Urban Areas” (Biasin et al, 2023), a set of cards was developed[36]. Each card presented an NBS, such as green roofs, permeable surfaces, and urban gardens, accompanied by the measured effectiveness of each solution as well as its associated implementation and maintenance costs. Each group proposed the ideal NBS for their high-risk area.

Following this, they calculated the area for each intervention, with respect to the scale of their maps, and using the information on the cards, they calculated the implementation and the maintenance (per year) costs.

They finally presented and discussed their ideas and findings with professionals and scientists in the related field, as well as representatives, including the Mayor, from the Municipality of Athens, proposing specific interventions in areas and schools of Athens. (§3.1.4).

Ellinogermaniki Agogi Primary School students (5th grade, 10-11 years old) contributed to the above findings regarding the benefits of NBS, with their results, part of the citizen science project in which they participated[37] for measuring the air quality of different areas of Attica (Figure 10). The students observed that areas with increased car traffic have a significant impact on the concentration of the air pollutant nitrogen dioxide, while in areas close to forests, the concentration of nitrogen dioxide is low. They thus conclude that trees are generally beneficial for reducing nitrogen dioxide in the atmosphere.

These two last activities, from the primary and secondary schools of Ellinogermaniki Agogi, based on various learning approaches, and as they presented NBS and their benefits in air quality and temperature, demonstrate how an effective learning pathway can be built within a school as NBS Living Lab.

[36] https://nbseduworld.eu/fileadmin/user_upload/Materials/NBSEduWORLD_NBSCards_EA.pdf
[37] https://www.green-scent.eu/

3.5 Invest in People

As described until now, the transformation of a school into an NBS Living Lab demands changes and orchestration of all the school's aspects. A crucial aspect, and the one that needs special attention and effort, is the people. The people who will, for the transformation of the school, envision, embrace, work, be engaged, support, guide, experiment, observe, make decisions, implement actions, evaluate outcomes, be empowered and trained, teach, and learn. At the core of this group are the teachers.

Teachers are not only enablers of student learning, but also active participants in their own learning journeys – reinforcing the idea that **schools must be spaces of learning not only for students, but for teachers as well**. At the centre of this is a robust *self-concept* – an inner anchor that enables teachers to firmly develop their professional agency, competences, and well-being (Beauchamp and Thomas, 2009; Day and Gu, 2010). This self-concept is more than a philosophical ideal; it is the steadfast anchor that enables teachers to navigate the surging currents of change, including the dynamic challenges related to green and digital transformations and AI integration[38]. This self-concept could also be the answer to the consistent teachers' reports of lack of motivation, support, and exhaustion.

When educators are anchored in ***being*** **(authentic self-awareness),** ***belonging*** **(mutually supportive relationships)**, and ***becoming*** **(continuous growth and transformation),** they are better equipped to remain resilient, innovative, and purpose-driven in today's complex educational environments (Palmer, 1997; Viac and Fraser, 2020). By integrating these dimensions into a strong self-concept, teachers establish a holistic foundation that supports enduring professional agency and well-being, while also advancing their expertise, experience, knowledge, skills, and attitudes.

A teacher's **professional identity** emerges over time through the interplay of experience, social interaction, and self-reflection (Hsieh, 2014; Beijaard, Meijer, and Verloop, 2004). It has critical importance to professional development and student learning. Identity is dynamic – shaped by systemic support, professional relationships, and ongoing reflection on teaching and learning (Suarez and McGrath, 2022).

When this identity is fortified by **dignity** – the recognition of one's expertise and worth – and by **unwavering integrity**, educators gain the confidence to uphold high standards even amid the uncertainties and pressures of today's rapidly changing societies (Kelchtermans, 2005; van Veen, Sleegers, and van de Ven, 2005). Anchored by such ethical assurance, teachers are better equipped to demonstrate enduring commitment and resilience, nurturing classroom environments built on trust and respect. In turn, students witness role models who embody authenticity, reinforcing their own sense of security and engagement[38].

This grounded identity naturally gives rise to a clear **sense of purpose**, a guiding force that illuminates why each lesson matters. Purpose-driven educators continuously reflect on their motivations and aspirations, weaving personal values into pedagogical choices (Gong and Wang, 2023). Such clarity not only elevates teacher well-being, fostering job satisfaction, motivation, and resilience (Beauchamp and Thomas, 2009; Day and Gu, 2010) but also transforms student experiences, sparking increased engagement, stronger self-efficacy, and

[38]OECD Teaching Compass for 2030

improved academic outcomes (Jennings and Greenberg, 2009). Yet this purposeful approach does not exclude spontaneity, as wise educators balance intentional objectives with emergent, play-based inquiry, creating space for student curiosity and creativity to flourish (Sutton-Smith, 2022; Lillard et al, 2013).

Underpinning both identity and purpose are the twin processes of **sense-making** and **meaning-making**, through which teachers interpret new information and integrate it into coherent professional narratives (Daloz, 2000; Stollman et al, 2020). By bringing reflective practice to the forefront – critically examining successes, learning from missteps, and continuously reauthoring their stories – educators transform everyday challenges into opportunities for innovation and growth (Beauchamp and Thomas, 2009). This reflective stance not only shields against burnout but also cultivates in students the inquisitiveness and resilience they observe modelled in their teachers.

In a truly collaborative school, the inner strength of each teacher's professional identity finds its fullest expression when interwoven with a profound sense of belonging. Far from being a mere byproduct of a positive school culture, belonging is the lifeblood of vibrant learning communities – a recognition that no educator operates in isolation but flourishes through reciprocal relationships across classrooms, staff spaces, and the wider ecosystem. Recent studies confirm that when teachers feel genuinely valued and connected, their emotional and psychological well-being improves, collaboration deepens, and turnover declines (Mishra and Oster, 2023; Viac and Fraser, 2020). In such environments, trust becomes the warp thread, underpinning every interaction, from day-to-day pedagogical decisions to long-term strategic change.

At the core of this fabric lies **psychological safety**, the conviction that one can speak up, ask difficult questions, or admit mistakes without fear of repercussion. When schools cultivate this atmosphere, teachers report higher job satisfaction and a greater willingness to experiment with new instructional strategies (Kelchtermans, 2017; Kachchhap and Horo, 2021; Bjorklund et al, 2020). This professional courage then extends into the classroom, as confident teachers model the resilience and risk-taking they wish to see in their students, fostering classrooms where curiosity thrives, mistakes become learning moments, and academic engagement deepens.

Equally vital are the **caring, empowering relationships** that bind educators to one another and families. When interactions among colleagues and school leaders are characterised by mutual respect and genuine support, teachers feel both seen and heard (Akinyemi, Rembe and Nkonki, 2020). These affirming connections act as a buffer against stress and burnout, elevating motivation and reinforcing a shared commitment to student success (Collie, Shapka, and Perry, 2012). In turn, students benefit as their teachers bring renewed energy and collaborative expertise into every lesson, modelling the social-emotional competence that underpins resilient, engaged learners (Jennings and Greenberg, 2009)[39].

Finally, a coherent **school ethos** and strong ties to **the wider community** give this fabric its scale and strength. Such ties are increasingly recognised as critical to strengthening teacher development and student learning, yet often require purposeful transformation to become more coherent, integrated, and supportive in practice (McGrath, 2023). When educators help shape

[39]OECD Teaching Compass for 2030

a school's vision and see that vision reflected, they develop a profound sense of ownership that wards off burnout and anchors their professional purpose (Dewey, 1986; Hargreaves and Fullan, 2015). Thoughtfully designed classrooms, versatile gathering areas, and inviting staff lounges signal that every voice matters (Barrett et al, 2013), while engagement with families and local organisations affirm teaching's vital role in society (Epstein, 2018). **Together, these multi-dimensional connections reinforce a culture of trust, respect, and interdependence, ensuring that when teachers are anchored by trust, the entire school community weaves together a resilient, flourishing fabric of belonging.**[40]

3.5.1 Promote continuous professional development and learning

In a school as NBS Living Lab, a collaborative approach among educators, school leaders, and professionals is key to an effective teaching ecosystem in implementing curriculum for a purpose. School leaders, including Principals, should create environments that promote continuous growth and innovation, which influences student outcomes (Leithwood, Sun and Schumacker, 2019; Fullan, 2014).

Teachers thrive in professional learning communities that support shared knowledge and interdisciplinary collaboration (Vescio, Ross, and Adams, 2008), since teaching is a lifelong journey of discovery, in which reflective practice and continuous learning propel teachers to meet new challenges and seize emerging opportunities (Mishra and Oster, 2023; OECD, 2019). Rather than a one-time qualification, professionalism should be a vibrant process of continuous professional learning (CPL), self-directed inquiry, and collaborative engagement. Teachers also need to lead by example in demonstrating how competence is developed through the continuous cycle of "anticipation-action-reflection".

CPL – which the OECD defines as a "lifelong process of ongoing learning and improvement" (OECD, 2024) – serves as both anchor and engine for this journey. When teachers pursue purposeful in-service development, they deepen subject-matter expertise, refine pedagogical skills, and reinforce the psychological foundations that support meaningful student relationships (OECD, 2019). Such sustained growth not only elevates classroom practice but also affirms the teacher's own identity as an evolving expert, one whose integrity and dignity are continually renewed through learning.

To build on this idea, growth and development need not be an isolated journey, especially when teachers have the agency to shape their own learning experiences. Self-directed learning (SDL) empowers teachers to diagnose their own needs, craft personalised goals, and select strategies that resonate with their aspirations (Knowles, 1975; Lan, 2022). Research shows that when educators chart their own paths – seeking out research, experimenting with new tools, and reflecting on outcomes – they experience greater motivation, pedagogical agility, and resilience in adapting to diverse student needs (Bhat and Dahal, 2023; Li, 2023)[40].

Crucially, SDL models for students the dispositions of curiosity and agency that educators wish to cultivate in the classroom (Roe and Perkins, 2024)[41]. Thus, in a school as NBS Living Lab:

[40] OECD Teaching Compass for 2030
[41] OECD Teaching Compass for 2030

- The school cultivates teachers' professional autonomy – the capability to defend classroom methods with a foundation in theoretical knowledge and critical reflection, along with a clear understanding of one's motivations and values in making decisions.
- The school includes a focus on CPL and CPD in its mission and annual action plan.
- The school allocates appropriate school time and resources for the teachers' "anticipation-action-reflection" cycle.
- The school establishes a procedure to detect and respond to teachers' needs for CPD and CPL.
- The school's leadership encourages teachers to use future perspectives to plan their long-term SDL.
- The school establishes procedures to make use of gains and achievements from CPD, as well as of the obstacles encountered, for the benefit of the whole school, especially for teachers not involved in initiatives.

Future-ready learners need strong skills. To build those skills, teachers need to act as much more than only traditional conduits of knowledge: they must serve as role models, guides, and facilitators of a supportive learning environment (OECD, 2024).

By guiding and empowering teachers, we guide and empower learners. And by investing in both, we invest in shaping the future we want – for education, for society, and the planet.

3.5.2 Inspiring Stories of Implementation

The Principal of the **Primary School of Zacharo** (Annex 1) took up duties in the 2023-24 school year. She has long experience and expertise, and a great vision for school education. Immediately upon her arrival at the school, she started working on the belief that "schools must be spaces for learning not only for students, but for teachers as well." To put her vision to transform the school into an NBS Living Lab for sustainability into action, the first thing she did was to follow a collaborative approach among the schoolteachers, herself, and external stakeholders, working on creating an environment that would promote continuous growth and innovation. By keeping informed and following initiatives and opportunities, she organised various training and learning activities for the school staff.

> "..this feeling that after 30 years of being in education, I can do something new and so beautiful, be useful, share and exchange with our students and others was incredible. An incredible feeling of renewal".
>
> Teacher leading the Primary School of Zacharo NBS Living Lab

In the context of NBS EduWORLD, teachers from the school participated in the community-building process, following the entire cycle of visionary-practice reflection-summative workshops as well as the training provided. After being engaged and motivated in the visionary workshop, the participation in the NBS EduWORLD International Professional Development Course 2024 followed, to develop the school's action plan. The course was attended by the Vice Principal and two teachers who led the overall implementation of the initiative,

demonstrating that the necessary preparation had been done in terms of leadership planning and support. The successful implementation, proved through the results and the reflection and summative workshops, as well as the interest of the participating teachers to evolve and expand the initiative – by participating in the CLEVERFOOD Summer School 2025[42] aiming to link the established school garden with sustainable food systems – demonstrated that the school followed an effective pathway in terms of investing in its people and promoting their professional growth.

Participation of the vice principal and 2 teachers in the NBS EduWORLD Summer School 2024 as part of the school's CPD strategy

The **Bougas School in Kalamata** (Annex 1) has an established plan regarding its participation in ERASMUS+ and eTwinning programmes at all levels of education and covering various thematic areas. The leadership of the school promotes extroversion and collaboration and is open to exploring new ideas and initiatives.

In the framework of NBS EduWORLD, one of the most experienced and expert teachers participated in the NBS EduWORLD International Professional Development Summer School 2024, following the vision of leadership but also his own SDL developed during the years of working in the school. Returning from summer school, the teacher initiated various processes regarding the actions needed to transform the school. Based on the trust and staff policies provided by the leadership, the strong collaborative environment and relationships among colleagues, and as a result the engagement of the students seeing the renewed energy and collaborative expertise of the teachers involved (Math, English, Biology, ICT) the teacher leading the initiative succeeded in getting the whole school community on board. It is worth highlighting that the challenges the team faced, with the most crucial one being the risk of the project's abandonment when no NBS could be found for the local issue explored – the increasing erosion of the eastern shoreline of Kalamata – were addressed due to the established purpose-driven and innovative culture of the school staff.

[42] https://esia.ea.gr/cleverfood-summer-school/#1674556150279-dcf6eddd-3c8e

Participation of the teacher leading the initiative in the NBS EduWORLD Summer School 2024

Ellinogermaniki Agogi (Annex 1) is a certified teachers training centre from the Greek Ministry of Education since 2002, serving thus the long-term vision and strategy of the school regarding CPD and CPL based on the belief that "when educators are anchored in being (authentic self-awareness), belonging (mutually supportive relationships), and becoming (continuous growth and transformation), are better equipped to remain resilient, innovative, and purpose-driven". And this is something that is not only a profound process for school staff, but has expanded beyond the school environment, organising large-scale training and courses at local, national, and international levels through the European School Innovation Academy[43], in which Ellinogermaniki Agogi is a founding member, as well as the EU-funded programmes and the ERASMUS+ Teacher Academies[44] in which it participates.

In the framework of NBS EduWORLD, the whole-school staff, including the heads of kindergarten, primary, lower, and upper secondary, foreign language, sports, and building maintenance, was mobilised, trained, and informed about NBS and their benefits at different levels, in collaboration with the Research and Development Department of the school. As a result, NBS mainstreamed in every aspect of the school, such as the infrastructure (§3.2.4), curriculum (§3.3.3), and openness (§3.1.4).

The two **Education Leaders Awards 2025** for the Primary School English Department and the Lower Secondary School for the nominations "Eco Warriors in English: Learning English and Acting for the Environment" exploring NBS and proposing experiential activities related to English language learning and "The Green School: A living lab of sustainability and innovation" accordingly, highly motivated and boosted the whole-school community demonstrating that the school follows an effective pathway in terms of investing in its people and promoting their professional growth.

[43] https://esia.ea.gr/
[44] https://education.ec.europa.eu/education-levels/school-education/erasmus-teacher-academies

The Lower Secondary School Vice Principal and the Primary School Head of the English Department receive the Silver Education Leaders Awards 2025 for the nominations 'The Green School: A living lab of sustainability and innovation' and 'Eco Warriors in English: Learning English and acting for the Environment'.
Together in the picture, the Chairman of the Jury Committee, the former EU Commissioner and former Prime Minister of Education of Greece, Anna Diamantopoulou and teachers, members of the R&D Department and the Principal of the Primary School of Ellinogermaniki Agogi getting Awards for other initiatives of the school.

English Teachers participating in an internal school training for integrating a Virtual Reality visit to a Pollinator Park into their classes

Presentation of Ellinogermaniki Agogi Lower Secondary School NBS Living Lab in the NBS EduWORLD Summer School 2025

4. Adopting the NBS EduWORLD Living Labs Roadmap

As mentioned in the introduction and thoroughly analysed in Chapters 2 and 3, schools that want or attempt to embark on an educational journey in NBS and transform their schools into vibrant, living labs for sustainability may adopt this roadmap. To do so, they need to follow the steps described in the sections below (Figure 14).

4.1 Guidance for schools to plan their actions of transformation

The first thing to consider is the level of knowledge and expertise they have regarding NBS and environmental education. If they have little to average NBS knowledge, it is recommended to start by following the Guidelines on Implementation of Nature-Based Solutions Activities in Education for Starters.

As they gain confidence, they can move gradually to the Guidelines on Implementation of Nature-Based Solutions Activities in Education for Advanced Educators.

Careful study and reflection on the NBS EduWORLD Living Labs Roadmap is the next step. Here, the school needs to conduct a self-assessment exercise and evaluate whether and to what extent it meets the criteria of an NBS Living Lab, as described in the roadmap. Additionally, it must identify areas for improvement and focus its work to enhance these areas. This exercise should be done with honesty, self-awareness, and objectivity, having a forward-looking perspective and considering that the objective is to develop and improve.

In doing so, the school will then be able to develop its "School as NBS Living Lab" Action Plan (Annex 3), describing its objectives and the planned actions regarding the curriculum, teaching and learning, openness and community practices, CPD and CPL, as well as infrastructure and operations.

4.2 Support during the journey of transformation

To support the implementation of the envisioned journey and planned actions, schools should seek guidance in the NBS EduWORLD Academy. The Academy is a pathway to training and CPD opportunities, communities of practice for science education and open schooling, innovative teaching and learning approaches, and resources, all related to NBS education (Figures 15, 16). Therefore, a school in the process of transformation can find inspiration, solutions, and guidance to support each parameter of its action plan.

Reflection (Annex 4) throughout the process is mandatory as it helps to get feedback, identify delays, challenges, and problems encountered, and how they were addressed or must be addressed. Furthermore, to make corrections or changes to the initial plan, discuss different or additional support needed, but also to celebrate achievements, praise, or encourage the people involved.

Finally, a similar self-assessment exercise to the one at the beginning should be done on lessons learned and impact, again with honesty, self-awareness, and objectivity.

Figure 14: Adopting the NBS EduWORLD Living Labs Roadmap

NBS EduWORLD Academy

Empowering educators to lead the way in NBS Education

The NBS EduWORLD Academy is dedicated to building a community of expert teachers ready to inspire the next generation to navigate real-world challenges through Nature-Based Solutions.

For this reason, and to ensure the long-term impact of NBS Education across Europe and beyond, the Academy:

- offers various training and learning opportunities,
- provides innovative teaching and learning approaches and tools to help educators design effective and engaging lessons, NBS projects, and living lab concepts,
- promotes Inquiry-Based Science Education,
- supports educators in their career professional development.

Schools as NBS Living Labs

Scenarios of Plausible Futures for NBS in Education

This document describes and analyses the different pathways for the transformation of the schools into NBS Living Labs through the Whole School Approach, providing a structured set of Scenarios of Plausible Futures for NBS in Education that can act as a reference point for the project's implementation with the large users' communities.

A Roadmap towards NBS Living Labs

The roadmap offers a guide for educators and school leaders to transform their schools into NBS Living Labs following the Whole School Approach. It highlights key stages from vision-setting and stakeholder engagement to planning and hands-on activities, while integrating innovative pedagogies such as inquiry-based learning.

It provides a structure to follow to facilitate the process of envisioning, managing, and monitoring change related to NBS in school settings. Grounded in real stories of implementation, it empowers schools to create meaningful, student-centered NBS environments.

How to develop my school's Action Plan

The template supports schools in developing their own 'School as NBS Living Lab' Action Plan by guiding them through a structured reflection and planning process.

How to conduct workshops using the Living Lab methodology

This ready-to-use worksheet supports the design and facilitation of hands-on workshops based on the Living Lab methodology. It guides students and educators through co-design, exploration, experimentation, and evaluation phases, helping them identify local NBS challenges, develop solutions, and test them collaboratively.

Inspiring Stories of Implementation

The NBS EduWORLD Schools Community shares moments of their journey in NBS Education.

Figure 15: NBS EduWORLD Academy (I)

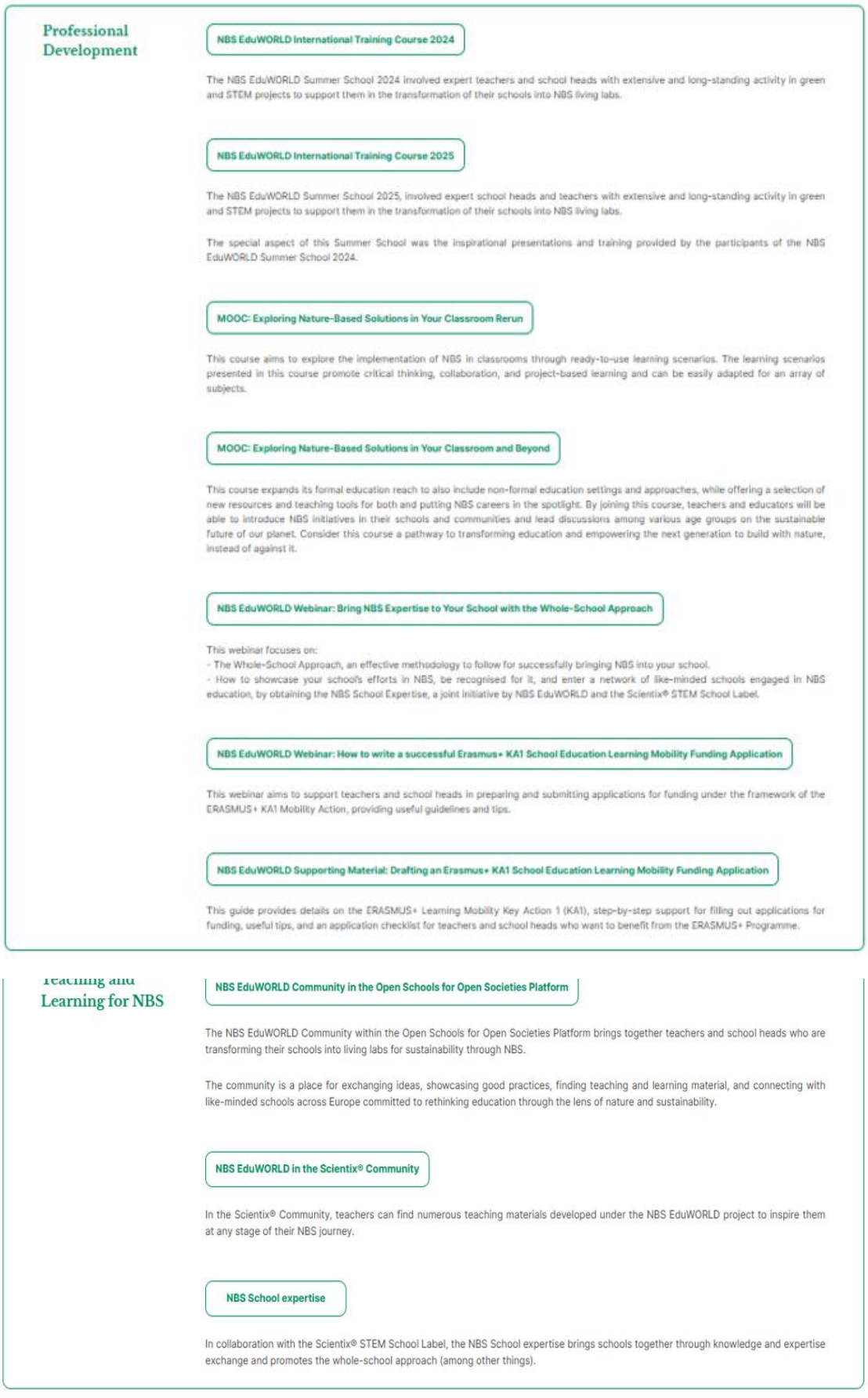


Figure 16: NBS EduWORLD Academy (II)

5. Conclusion

The initial starting point for mainstreaming NBS and transforming schools into NBS Living Labs was the project team's acknowledgement that introducing innovation in educational settings may lead one school to flourish, while another school erects barriers. What it needed was a big-picture vision: a habit of asking not merely “what works here?” but “what works together?”. Whole-system thinking was used as it invites us to zoom out, trace interdependencies, and resist the lure of simple answers. It calls us to integrate multiple perspectives, search for patterns rather than points, and hold several truths at once.

This thinking was the lighthouse for the NBS EduWORLD Living Lab Roadmap’s journey, and it turned out that a shift towards a Whole School Approach is not only strategic but profoundly humane. It replaces certainty with curiosity, control with collaboration, and reaction with reflection. By moving beyond either/or logic toward systemic coherence, we equip ourselves to navigate the turbulence of innovation, disruption, and crisis. More importantly, we gain the perspective to craft futures that are not just efficient or productive, but also sustainable, equitable, and deeply life-affirming (OECD, 2025).

Through the overall work and results of WP6, it appeared that following the WSA has an obvious impact on the openness of the schools, the integration of NBS education, and the level of innovation, transforming them into NBS Living Labs. Schools that embraced the WSA at a higher level, consistently following and working on more or all its pillars, showed a higher level of innovation and integration of NBS.

Furthermore, the higher the level of supportive policies and initiatives in place and followed by innovative schools, consisting of or led by NBS expert teachers/Principals, the level of innovation increases. In fact, the level of innovation increases significantly in less innovative schools. The key point is that although top-down and bottom-up approaches represent contrasting strategies, their combination in a balanced way (where the strengths of one approach overcome the weaknesses of the other) could catalyse the diffusion of innovative concepts and ideas, like NBS, in the traditional school environments. When local, context-specific needs and initiatives of the school communities are integrated to standardised approaches driven by the EU or the national educational authorities, the potential of the process to bring sustainable change is unique.

Based on evidence and the inspiring stories of implementation from the NBS EduWORLD Living Labs, WP6 drafted this roadmap to provide a structured path for embedding environmental and social responsibility and active sustainability citizenship into school education, by guiding schools in reimagining infrastructure, curricula, teaching and learning, and community practices, inspired by NBS and leveraging their power to solve real-world challenges.

The NBS EduWORLD Living Labs Roadmap can serve as a reference and guidance document for educational stakeholders to create vibrant, future-ready learning environments, that will act as NBS Living Labs, where learning and acting for sustainability are not just taught but lived and practiced holistically on a permanent basis, thus supporting substantially the long-term strategy of mainstreaming NBS in education and the vision of schools as NBS Living Labs.

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Annexes

Annex 1. Profile of the Schools acted as Case Studies

(1) Kindergarten of Klimatia, Ioannina, Epirus, Greece	
Short Description	The Klimatia Kindergarten is co-located with the Klimatia Primary School in a stone building that was constructed in 1932. The school's policy is based on the sociocultural theory of Activity and the belief that learning is the result of interaction. A key priority is "openness" and the expansion of the learning environment beyond the classroom, through the implementation of formal, non-formal, and informal teaching methods, where the students' natural, social, and cultural environment is utilized as a primary source of knowledge. To effectively cultivate skills and support the balanced and holistic development of young learners, the school employs, among other methodological tools, the sociocultural approach to STEAM education and educational robotics. Special emphasis is placed on the use of artificial intelligence applications, augmented reality, and 3D Design, as well as on the proper utilization of the possibilities offered by digital technology. The outcomes of these applied initiatives are disseminated by the teaching team to the children's families, the local and wider community, as well as through nationwide and international educational/student conferences, summer schools, workshops, and seminars, aiming to share the results produced. The overall positive evaluation, along with the numerous awards and distinctions received by the school, resulting from the consistent and long-term implementation of this applied learning approach, confirm the effectiveness of the school's policy and encourage the continuation and constructive expansion of its innovative activities. http://nip-klimat.ioa.sch.gr/
Number of Students **Number of Staff**	9 1
Student Ages	4-6
Experience/Activities in Environmental and Sustainability Education	Awarded Eco School and Sustainable School since 2012 https://www.ecoschools.gr/schools/nipiagogeio-klimatias
Experience/Activities in STEAM Education	Long-term implementation of STEAM education pilot programs, carried out in collaboration with the Laboratory of Natural Sciences and Education for Sustainability of the Department of Education of the University of Ioannina, as part of the doctoral thesis of the school's teacher (https://atfisegroup.ecedu.uoi.gr/people/topoliati/) Participation in international educational programs and networks: Unesco Aspnet School Network, CodeWeek4All (Leading Teacher, Awarded: Certification of Excellence and Super Organizer) Creativity in Early Years Science Education (CEYS), Reflecting for Change, Open Schools for Open Societies, Playing with Protons, Discovery Trails, Seismolab, SALL, Learning about Ecosystems and Forests, Open Technologies in Education Competition, STEAM Competition: WRO Hellas, E-Twinning, European Space Agency (ESA) educational programs Space Gallery Competition: (European Space Agency Educational Team) Astro-Pi Challenge Mission Zero, Train like an Astronaut, Moon Camp Challenge

(2) 1st Primary School of Zacharo, Elis, Peloponnese, Greece	
Short Description	https://dim-zachar.ilei.sch.gr/
Number of Students **Number of Staff**	248 34
Student Ages	6-12
Experience/Activities in Environmental and Sustainability Education	Environmental education SDGs
Experience/Activities in STEAM Education	Eratosthenes experiment Space Education School Seismograph Physics Lab

(3) 4th Primary School of Pefki, Attica, Greece	
Short Description	http://4dim-pefkis.att.sch.gr/site/
Number of Students **Number of Staff**	166 30
Student Ages	6-12
Experience/Activities in Environmental and Sustainability Education	Environmental education and SDGs
Experience/Activities in STEAM Education	STEM

(4) 9th Primary School of Rethymno, Crete Island, Greece	
Short Description	The Efeperi School Garden is an organic, student-driven educational space designed to bring sustainability and hands-on learning into the schoolyard. Children explore ecology, nutrition, and math through planting aromatic Mediterranean herbs, designing garden layouts, and budgeting for tools, all as part of inquiry-based workshops. The project fosters a sense of environmental stewardship and community, integrating cross-curricular themes like art, geography, technology, and teamwork. It transforms the garden into a micro-lab where students learn how local plants thrive, practice responsible habits, and grow into environmentally aware citizens. http://9dim-rethymn.reth.sch.gr/
Number of Students **Number of Staff**	205 35
Student Ages	6-12

(4) 9th Primary School of Rethymno, Crete Island, Greece	
Experience/Activities in Environmental and Sustainability Education	Since the 2006–2007 school year, we have been exploring the idea of creating and developing a school garden through a modern approach to organic cultivation of plant species, integrated into the teaching and learning content of an educational process oriented toward practical and experiential environmental action. A school garden, with the appropriate structure and educational function, can serve as a micro-level model of sustainable development, promoting ecological awareness and holistic management of products and energy resources. Every corner of the garden can become a small laboratory for studying and understanding delicate environmental balances and their impact on modern human life Project link: http://efepereth.wikidot.com/garden-intro
Experience/Activities in STEAM Education	**Strong STEM background** due to the **Primary Science Laboratory** affiliated to the School, with participation in science fairs and festivals, and participation in many EU Projects in STEM/Science Education, etc. (cf. http://efepereth.wikidot.com/)

(5) 6th Lower Secondary School of Volos, Magnesia, Greece	
Short Description	Our school was founded in 1984, and it is inclusive since it accommodates 36 Roma students, children with special abilities, but we all cooperate with perfect harmony. We cooperate with schools in our region, both at the primary and secondary levels, but we also work with schools from other countries through ERASMUS+ programs within the scope of sustainability and climate change. We are constantly working with the Municipal authorities of our city, who help us in cleaning the outdoor areas, trimming trees, and offering free flowers and trees. https://6gym-volou.mag.sch.gr/wpsite https://www.facebook.com/6gymvolou
Number of Students **Number of Staff**	270 30
Student Ages	12-15

(6) Bougas School, Kalamata, Messinia, Peloponnese, Greece	
Educational Level:	Kindergarten to Upper Secondary
Short Description	Bougas School in Kalamata is a private, all-day educational institution that offers a comprehensive academic program from daycare to high school. With a strong emphasis on creative, student-centered learning and bilingual education, the school fosters critical thinking, personal growth, and social responsibility, living up to its motto: “Student of today… citizen of tomorrow.” Its interdisciplinary curriculum includes Greek and foreign languages, sciences, arts, IT, and enhanced support for national university exams. The school is also known for its innovative projects. A flagship initiative was the space experiment with Blue Origin in collaboration with Ellinogermaniki Agogi, where students designed a scientific payload to study the behavior of Messinian olive oil in microgravity, a project that launched into space in 2019. Students are also engaged in math competitions, robotics, STEAM

(6) Bougas School, Kalamata, Messinia, Peloponnese, Greece	
	programs, and community science initiatives, fostering both scientific inquiry and teamwork. https://bougas-school.gr/?lang=en
Number of Students **Number of Staff**	600 150
Student Ages	6-18
Experience/Activities in Environmental and Sustainability Education	Bougas School actively promotes sustainability education through its participation in the Erasmus+ project F.R.E.S.S.H. (Food, Recipes, Sports, Sustainability, and Health). This international initiative engages students in exploring the links between healthy living and environmental responsibility. Through activities like tree planting, eco-trails, outdoor sports, and workshops on the Mediterranean diet, students develop ecological awareness and sustainable habits. International exchanges with partner schools in Spain, Bulgaria, and beyond offer hands-on experiences that connect personal well-being with care for the planet.
Experience/Activities in STEAM Education	Bougas School, in collaboration with Ellinogermaniki Agogi and spaceflight company Blue Origin, designed and implemented a pioneering space experiment. The experiment, which involved observing the behavior of Messinian olive oil under microgravity conditions, was launched into space in 2019. This initiative was the result of three years of preparation and interdisciplinary collaboration, fostering students' creativity and passion for science, and bringing Messinia, and its olive oil, one step closer to the stars. Links 1: https://www.kathimerini.gr/society/1022930/to-messiniako-ladi-sto-feggari/ Link 2: https://www.schoolofthefuture.eu/en/osos/news/osos-schools-greece-send-olive-oil-space

(7) Evangeliki Model Upper Secondary School of Smyrna, Attica, Greece	
Short Description	Our goal at the Lyceum is not only to provide knowledge to our students and prepare them for university entrance exams, but more importantly, to shape their character through close cooperation based on mutual respect and adherence to school rules. Believing that a school should offer students the opportunity to develop their skills, showcase their talents, and cultivate their research mindset, we strive, within the limits of our existing infrastructure, to develop programs and clubs (also open to students from other schools) through which students can fulfil their desire for something beyond a simple "lesson." https://lyk-evsch-n-smyrn.att.sch.gr/
Number of Students **Number of Staff**	270 25
Student Ages	16-18
Experience/Activities in Environmental and Sustainability Education	Participation in the international project "Act Now for the UN Sustainable Development Goals – SDGs in STEM Education," which began in February 2020 and concluded in October 2022, along with 20 other educators from various European countries. The project aimed to produce educational materials to integrate the 17 Sustainable Development Goals into the STEM (Science, Technology, Engineering, Mathematics) curriculum.

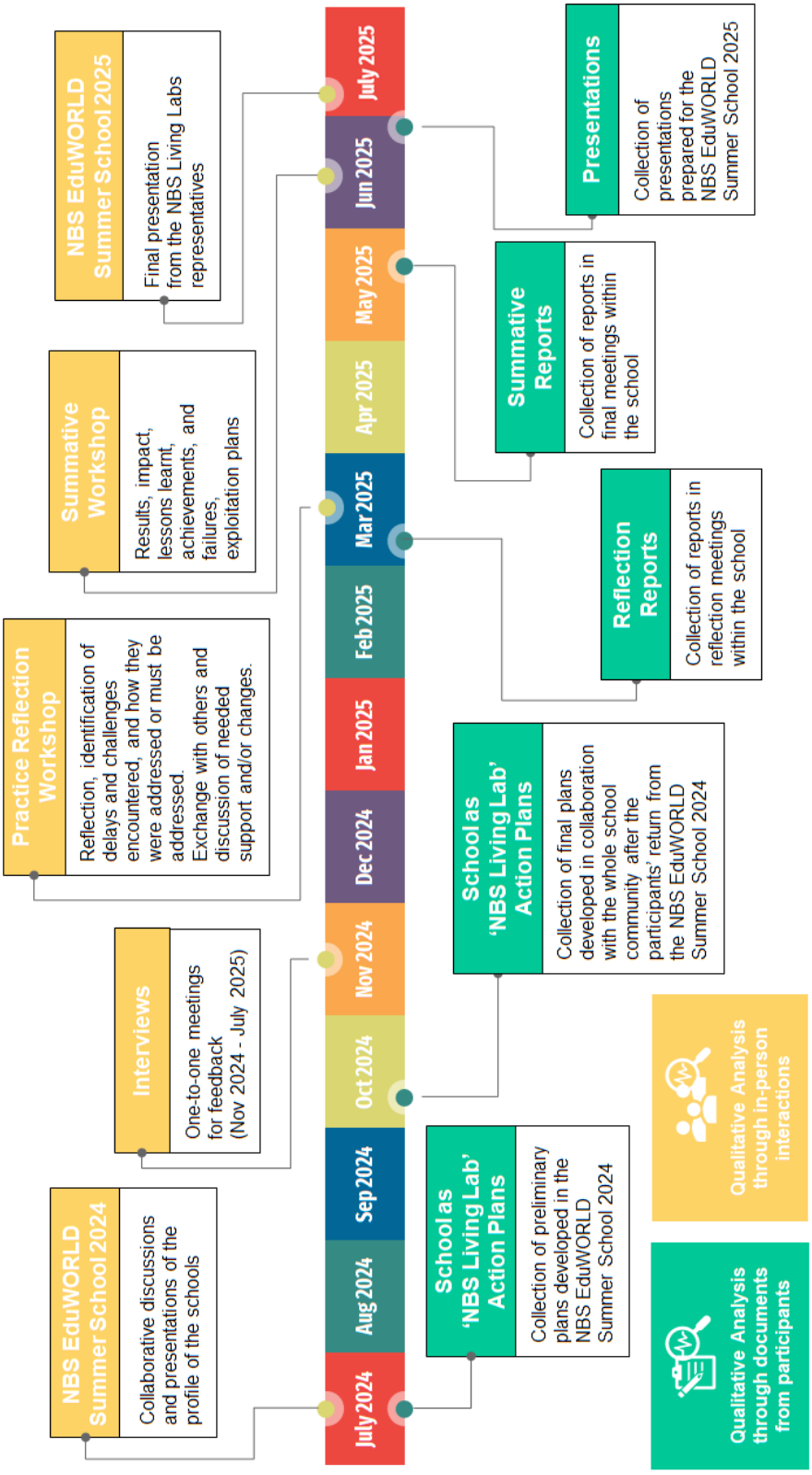
(7) Evangeliki Model Upper Secondary School of Smyrna, Attica, Greece	
	Project link: https://www.science-on-stage.eu/act-now-sdg
Experience/Activities in STEAM Education	HORIZON2020: «Open Schools for Open Societies-OSOS» ERASMUS+ KA3: «Reflecting for Change - R4C»

(8) 1st Upper Secondary School of Lamia, Phthiotis, Greece	
Short Description	Our school actively fosters environmental awareness among its students through participation in both school-based environmental programs and European Erasmus+ initiatives. As a member of the international Eco-Schools network, we maintain a strong commitment to sustainability. The school's environmental team, consisting of approximately 60 students, collaborates with numerous Environmental Education Centers and regularly engages in a variety of impactful environmental activities. http://1lyk-lamias.fth.sch.gr/
Number of Students **Number of Staff**	310 40
Student Ages	15-18
Experience/Activities in Environmental and Sustainability Education	Every year, our school implements environmental education programs and collaborates closely with Centers for Environmental Education and Sustainability to promote awareness and action among students

(9) Ellinogermaniki Agogi School, Pallini, Attica, Greece	
Educational Level:	Kindergarten to Upper Secondary
Short Description	Ellinogermaniki Agogi has a very strong vision-generated interest and rich research and development activities in the fields of Inquiry-Based Science Education (IBSE), Project-Based Learning (PBL), and STEM education in combination with digital, online-based learning environments and tools that use virtual reality, augmented reality, and storytelling. Ellinogermaniki Agogi is continuously modernizing STEM education by promoting and creating user-driven learning environments for students and offering numerous opportunities for teachers' professional development. Moreover, a large range of projects are focused on developing and implementing technological tools that leverage both digital science repositories and IBSE/PBL learning. Ellinogermaniki Agogi is a Certified Centre for Teachers' CPD since 2002. Established in 1995, the Research and Development Department of EA is guiding the introduction of innovation in the school setting. The R&D Department acts as an interface between the pedagogical research, the technological innovation, and the school community. It focuses on the design, implementation, and support of pedagogical and technological innovation in educational practice, both through internal research as well as through collaborations with numerous educational, research, and commercial institutions. Ellinogermaniki Agogi is a founding member of the European School Innovation Academy (ESIA - https://esia.ea.gr/) and has a very strong and proven experience in actively extending the dialogue between scientific and the educational community, enforcing the collaboration between schools and research organizations, centers and museums, and helping young people to acquire

(9) Ellinogermaniki Agogi School, Pallini, Attica, Greece	
	better understanding of the role of science in society. In this framework, it has coordinated large-scale policy experimentation actions like the Reflecting for Change Initiative (https://reflecting4change.eu/) and Coordination Actions like the Open Schools for Open Societies (https://www.openschools.eu/) that are introducing the concept of open schooling to numerous schools in Europe. https://ea.gr/en/index.asp
Number of Students **Number of Staff**	2000 250
Student Ages	5-18
Experience/Activities in Environmental and Sustainability Education	Through the numerous EU projects in which Ellinogermaniki Agogi participates or coordinates, the whole school community implements activities and gains experience in Environmental and Sustainability Education. Below are some of them: https://eco2-schools.eu/ https://synapses-academies.eu/ https://climademy.eu/ https://www.green-scent.eu/ https://food2030.eu/projects/cleverfood/ https://seemik.tlu.ee/discovery-trail-project/ https://schoolsgogreen.eu/ https://innature-project.eu/the-project/ https://www.pro-coast.eu/en/c https://otters-eu.aua.am/
Experience/Activities in STEAM Education	Through the numerous EU projects in which Ellinogermaniki Agogi participates or coordinates, the whole school community implements activities and gains experience in STEAM/STEM Education. Below are some of them: https://discoveryspace.eu/ https://surroundedby.science/ https://ai4edu.eu/ https://explore-project.eu/ https://projectstand.eu/ https://seismolab.gein.noa.gr/ https://aiwareproject.eu/ https://soundscapes.nuclio.org/ https://www.steamecologies.eu/ https://www.road-steamer.eu/

Annex 2. Methodology used for Qualitative Analysis


July 2024
Aug 2024
Sep 2024
Oct 2024
Nov 2024
Dec 2024
Jan 2025
Feb 2025
Mar 2025
Apr 2025
May 2025
Jun 2025
July 2025
NBS EduWORLD Summer School 2024
Collaborative discussions and presentations of the profile of the schools
School as 'NBS Living Lab' Action Plans
Collection of preliminary plans developed in the NBS EduWORLD Summer School 2024
Interviews
One-to-one meetings for feedback (Nov 2024 - July 2025)
Practice Reflection Workshop
Reflection, identification of delays and challenges encountered, and how they were addressed or must be addressed.
Exchange with others and discussion of needed support and/or changes.
Summative Workshop
Results, impact, lessons learnt, achievements, and failures, exploitation plans
NBS EduWORLD Summer School 2025
Final presentation from the NBS Living Labs representatives
School as 'NBS Living Lab' Action Plans
Collection of final plans developed in collaboration with the whole school community after the participants' return from the NBS EduWORLD Summer School 2024
Reflection Reports
Collection of reports in reflection meetings within the school
Summative Reports
Collection of reports in final meetings within the school
Presentations
Collection of presentations prepared for the NBS EduWORLD Summer School 2025
Qualitative Analysis through in-person interactions
Qualitative Analysis through documents from participants

Annex 3. "School as NBS Living Lab" Action Plan Template

What does it mean for a school to be an NBS Living Lab

A school as NBS Living Lab is both inward and outward-looking and open in order to create a healthy habitat that invites and supports NBS and sustainability. It has adopted the concept of **open schooling** and it's an agent of community well-being by creating new partnerships with other local actors and addressing local issues relevant to them.

In a school as NBS Living Lab, **students explore issues, relevant not only to themselves but also to others, and community partners can offer insights, but also benefit from students' interest, research, and creativity.** The students are more rooted in their habitat and gain a sense of place and connectedness. For example, students, parents, and staff, with the support of a local NGO and the local authorities, can grow their food in a community garden or the school garden, and use that food in the school canteen or provide it to those in need.

The teaching and learning are interdisciplinary and transformative. The learning methods and approaches are collaborative, experiential, inquiry and problem-based, practically oriented, and relevant to local contexts. Much of the learning does not take place inside the classroom, but also in other spaces inside and outside the school building, as well as in the local community, in the marketplace, at the library, the museums, and through playing, reading, and sports activities. Visiting also a restored wetland or participate in its restoration. The boundaries between formal, informal, and non-formal learning are indistinct.

Basic pillars of education, such as design, content, and assessment for each topic are reflected throughout the curriculum considering the competences that are being developed. The development of the knowledge, skills, and attitudes of learners of all ages to live and act sustainably are supported by the **GreenComp**: the European sustainability competence framework which has been designed to support education and training programmes for lifelong learning. For example, by participating in the design and implementation of a pocket park, students develop competences such as promoting nature, supporting fairness, thinking critically, and acting for change. Bringing real-life projects to the classroom support also the development of 21st century skills.

A school as NBS Living Lab acts as a learning building for sustainability. For example, it controls energy and water usage, waste management, the kind of food and nutrition offered, or the labeling of food options in the canteen menu so that students are aware of the environmental impact of their choices. It operates an organic school garden that, apart from acting as an open educational environment for all students, produces a significant amount of vegetation consumed in the school canteen. Or it reconstructs the schoolyard in a green space, and therefore a “cool island” during heatwaves, with the participation of students and external stakeholders in the co-design of the schoolyard, in the selection of the plants according to their characteristics and in the process of the planting. Thus, apart from acting as an educational environment for all students, it reduces runoff, helps filter pollutants, and enhances biodiversity by providing food and shelter for butterflies, songbirds, and other wildlife. By interrogating, rethinking, and redesigning institutional practices, the hidden curriculum of unsustainability that is often present can be exposed and addressed.

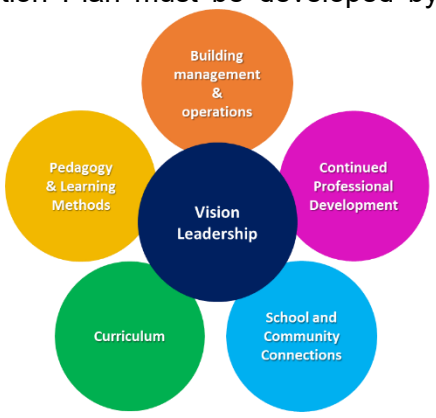
In a school as NBS Living Lab, all educators, whatever their discipline or sector of education, are considered sustainability educators who need to support their learners in preparing for the green transition. For this reason, they have the expertise and continuous training opportunities to feel sufficiently equipped. Professional development is also relevant to all staff groups working at schools, e.g., those who clean the building, run the school canteen, maintain the buildings and the school grounds, etc.

Becoming an NBS Living Lab cannot be seen as an isolated 'project', as it demands a root and branch rethink, not just in pedagogies or the curriculum, but in every aspect of the school structure: its vision, culture, and the use of space, place, and time. Similarly to the Open Schooling concept, a school must act as an open, curious, creative, welcoming, and democratic environment that is supposed to support the development of innovative educational activities (Sotiriou et al, 2021). To this end, the vision of the NBS Living Labs is to create seamless and continuous learning pathways at all education levels, nurturing in parallel the understanding and implementation of NBS. By incorporating NBS principles and practices into the curriculum, students will develop the key competences towards pro-environmental behavior and action for addressing complex sustainability challenges. Therefore, schools have the potential to transform into incubators of social innovation where NBS acts as an enabler of the **Whole School Approach**.

The Action Plan of a School as NBS Living Lab

To **transform a school into an NBS Living Lab** an Action Plan must be developed by describing the strategies and activities the school community needs to design and follow to integrate NBS in its settings regarding each pillar of the Whole School Approach. Thus, a reflection and working process is needed on:

- The learning methods and pedagogies to be followed.
- The links to the curriculum for greening it and reaching a competence-based curriculum.
- The possible interventions inside and outside the school building and how these could be linked to the educational process.
- Which and how different societal actors will be involved and mobilized.



Whole School Approach

- The strategy to be followed for the professional development of the staff.

The Action Plan of my School as NBS Living Lab

Presentation of my school

Name:	
Level of Education ***Short Description***	
Area	☐ Urban ☐ Rural ☐ Coastal
Number of students ***Number of classes*** ***Number of staff (teaching and administrative)***	
Age of students	
Environmental/Sustainability Education background	
STEM Education background	

Summary

Describe the main idea of your NBS intervention and how you came up with it (needs/problems/challenges). Briefly present the envisaged activities, the timeline, and the results you expect.

Objectives

Describe the **learning objectives** of your action plan and which of the **twelve NBS societal challenge areas** the Nature-Based Solution you will propose will address (**environmental and social objectives**).

Learning Objectives	
NBS Societal Challenge Areas ***Environmental and Social Objectives***	☐ Air quality ☐ Biodiversity enhancement ☐ Climate resilience ☐ Green space management ☐ Health and well-being ☐ Knowledge building for sustainable urban transformation

	☐ Land regeneration ☐ Natural and climate hazards ☐ New economic opportunities and green jobs ☐ Participatory planning and governance ☐ Social justice and social cohesion ☐ Water management

Learning Methods and Curriculum

What learning method(s) will you apply to integrate NBS in your teaching?

→

Do the learning methods serve your learning objectives and how?

→

Will you offer experiential, hands-on learning opportunities that connect students to nature?

→

Will the NBS activities support diverse learning styles? If yes, explain how.

→

How will you integrate NBS into your school's curriculum? Give details regarding the disciplines involved, the content (development of educational materials to support teaching), and the schedule/hours.

→

How will Inquiry-Based Science Education (IBSE) be addressed in your (NBS) curriculum?

→

Will the (NBS) curriculum promote interdisciplinary connections? If yes, how will different lessons be linked around sustainability and NBS?

→

Will you connect the formal curriculum with informal and non-formal learning opportunities and how?
***Reflection Aspect**: Consider how informal and non-formal learning activities (like fieldwork, outdoor lab experiences, visit to a museum or activities, for example at home, complement the formal curriculum. How will students be engaged beyond the classroom?*

→

Will the (NBS) curriculum promote the GreenComp Framework and how?
*(**GreenComp** Framework: Embodying sustainability values, such as supporting fairness and promoting nature, acting for sustainability - individual, collective, political - envisioning sustainable futures, being adaptable, exploratory, systems and critical thinking, problem framing)*

→

Will the (NBS) curriculum promote soft and digital skills and how?

→

Can the (NBS) curriculum create a continuous learning pathway between different classes, disciplines, and activities of the school (e.g. after-school programs)? If yes, explain how.

→

Will you incorporate in the curriculum the monitoring or/and the assessment of students' development of sustainability competences, and if yes how?

Building management and operations

Will you use the school's infrastructure and daily operations as a field of learning for NBS and sustainability and how?

→

Will you integrate specific Nature-Based Solutions (NBS) into the school's infrastructure and daily operations and which? (e.g., green roofs/walls, rainwater harvesting, schoolyard interventions, school garden, outdoor classrooms).

→

School and Community Connections

Will you establish partnerships with societal actors, such as parents, local authorities, environmental organizations, businesses, NGOs, or universities to support the planned activities? If yes, with whom?

→

Will you pursue and facilitate knowledge-sharing and collaboration with other local or national schools working on NBS projects and activities? If yes, give details.

→

Could your planned activities address local environmental challenges and impact the local community? If yes, how?

→

What will your school do to share the results of its activities and knowledge gained?

→

Continuous Professional Development

How will you enhance peer-to-peer learning and collaboration between colleagues for the NBS activities?

→

Are you planning to participate in training/professional development activities related to NBS and sustainability, and if yes what are they?

→

How will you address challenges related to time and resources for training?

→

Do you plan to collaborate with external experts to support capacity building for NBS and if yes with whom?

→
Are you planning to apply for Erasmus+ Key Action 1 (KA1) to support your professional development? If not, why?

→
Are you planning to collaborate with international school(s) to develop your NBS activities through eTwinning or small-scale Erasmus+ Key Action 2 (KA2)? If not, why?

→

Resources

"Nature-based solutions (NBS) are solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits, and help build resilience. Such solutions bring more and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient, and systemic interventions. Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services."
Source: https://research-and-innovation.ec.europa.eu/research-area/environment/nature-based-solutions_en

List of recent EU publications on nature-based solutions
Repositories: NetworkNature, Oppla, and Urban Nature Atlas
EU's strategy for protecting the climate: European Green Deal
EU's Biodiversity Strategy 2030
List of available resources, including guidance, reports, tools, and services developed around education about NBS: https://nbseduworld.eu/resources
Schools as Living Labs Resources: https://www.schoolsaslivinglabs.eu/resources/
Schools as Living Labs Community Platform: https://www.schoolofthefuture.eu/en/sall
NBS EduWORLD Webinar: How to write a successful Erasmus+ KA1 funding application
Erasmus+ Opportunities: https://erasmus-plus.ec.europa.eu/resources-and-tools/how-to-apply/where-to-apply

Annex 4. Guiding Questions for Reflection and Summative Workshops

Summary

From the Action Plan: Please describe the NBS intervention/action you are planning and explain how you arrived at this decision (needs, challenges, problem to be addressed). Briefly present the planned activities, the timeline, and the expected outcomes.

What is the status of the project, considering the initial plan?

Describe any problems, delays, and how you addressed them. Indicate any changes made to your original design.

What are the outcomes achieved so far? To what extent have the expected results been met?

What was implemented according to the original plan? Was the plan completed?

What advice would you give to someone wishing to carry out a similar activity?

What difficulties or challenges did you encounter during the project?

Teaching/Learning Methods and Curriculum

From the Action Plan: Which learning method(s) will you apply to integrate NBS into your teaching?
Will you provide experiential learning opportunities that connect students with nature?
Will the activities support different learning styles (e.g., visual, auditory, kinesthetic)? If so, please explain how.
How will the Inquiry-Based Science Education (IBSE) Model be reflected or incorporated into the proposed activity?

Feedback regarding the above.

Were there any additional activities beyond the initial design?

Problems encountered during implementation and how you addressed them.

Alternative solutions/strategies you applied.

Outcomes achieved so far.

What kind of support would help you improve the outcomes?

From the Action Plan: How will you integrate Nature-Based Solutions into your school's curriculum? Provide details regarding the disciplines involved, the content (development of educational material to support teaching), and the scheduling of hours.
Will the proposed activity promote interdisciplinarity? If so, how will different subjects be connected through environmental and sustainability education?
Will you link the formal curriculum with informal and non-formal learning opportunities, and if so, how?
***Reflection aspect:** Consider how informal and non-formal learning activities, such as fieldwork, outdoor experiments/activities, visiting a museum, or extracurricular activities, complement the formal curriculum. How will students be engaged beyond the classroom?*

Feedback regarding the integration into the school curriculum.

Problems encountered during implementation and how you addressed them.

Alternative solutions/strategies you applied.

Outcomes achieved so far.

What kind of support would help you improve the results?

*From the Action Plan: Will the proposed action promote the European sustainability competence framework **GreenComp**, and how?*

Will the proposed action foster soft and digital skills, and how?

Will you incorporate the monitoring and/or assessment of students' sustainability competences development into the proposed action, and if so, how?

Feedback regarding the above.

Do you have any indications as to whether the above has been achieved? If so, what are they?

If not, how do you think you could obtain such indications?

What kind of support would help you in relation to the above?

From the Action Plan: Can the proposed activity create a continuous learning pathway across different classes, disciplines, and school activities (e.g., the all-day program)? If yes, please explain how.

Feedback on the above, based on the results obtained so far.

Building Management and Operations

From the Action Plan: Will you integrate the school's infrastructure, its different areas (sports facilities, yard, building), and/or its operations into the educational process, and if so, how?

Will you implement any specific technical intervention by applying a Nature-Based Solution within the school environment, and if so, which one (e.g., green roof/wall, rainwater harvesting, green interventions in the schoolyard or the sports facilities, school garden, outdoor classroom)?

Feedback on the above, if you have included them in your action plan or if you added later .

Challenges encountered during implementation and how you addressed them.

Alternative solutions or strategies you applied.

Outcomes achieved so far.

What kind of support would help you improve the outcomes?

School and Community Connections

From the Action Plan: Will you establish collaborations with stakeholders, such as the parents' association, local authorities, environmental organizations, businesses, NGOs, or universities, to support the planned activities? If yes, with whom?

Will you seek and facilitate the exchange of knowledge and cooperation with other local or national schools engaged in similar projects and activities? If yes, please provide details.

Could the proposed action address local environmental challenges and have an impact on the local community? If yes, how?

What will your school do to share the outcomes of its activities and the gained knowledge?

Feedback regarding the above actions (for those included in your action plan).

Who did you collaborate with, and who supported you in implementing the activities?

In what way and with which individuals or organizations did you share the outcomes?

Challenges encountered during the implementation and how they were addressed.

Alternative solutions or strategies you applied.

Outcomes achieved so far.

What kind of support would help you improve the results?

Professional Development and Capacity Building

From the Action Plan: How will you promote peer learning and collaboration among colleagues in relation to the proposed activity?

Do you plan to participate in training or professional development activities related to Nature-Based Solutions and sustainability, and if so, which ones?

How will you address the challenges related to the time and resources required for training?

Do you intend to collaborate with external stakeholders (e.g., universities, professionals, research institutions, training centers) to support training, and if so, which ones?

Do you plan to apply for Key Action 1 (KA1) of the Erasmus+ programme to support the learning mobility of your school staff? If not, why?

Do you plan to collaborate with international schools/organizations/institutions to enhance your activities in environmental education and Nature-Based Solutions through eTwinning or small-scale partnerships under Key Action 2 (KA2) of Erasmus+? If not, why?

Feedback on the above (regarding what you have included in your action plan).

Did you participate in training or professional development activities related to Nature-Based Solutions and sustainability, and if so, which ones?

Did you apply for KA1 or KA2?

Challenges encountered during implementation and how you addressed them.

Proposed solutions/strategies you applied as alternatives.

Outcomes achieved so far.

What kind of support would help you improve the outcomes?

Project partners

NBS EduWORLD

nbseduworld.eu