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Kids Lab for Sustainability

**Report on the implementation
of the international project**

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Basic information about the project

Project Number: 2021-1-PL01-KA220-SCH-000034345

Funded by the European Union under the Erasmus Plus program, KA220-SCH—Cooperation Partnerships in School Education.

The international project team consisted of two foundations from Poland (coordinator) and Italy (Milan), as well as three universities from Spain/Catalonia, Ireland, and Italy (Rome). The fourth university collaborating with the Ignatianum Foundation (Poland) was the Ignatianum University in Cracow (associated organization).

The project ran for 30 months, from January 1, 2022, to June 30, 2024.

In line with the project's objectives, the team pursued three Erasmus Plus priorities:

1. HORIZONTAL priority: Environment and fight against climate change and from the SCHOOL EDUCATION sector.
2. Developing high quality early childhood and care systems
3. Promoting interest and excellence in science, technology, engineering, and mathematics (STEM) and STEAM approaches.

The project was structured around three main areas:

- Science, technology, engineering, arts and mathematics (STEAM);
- Early Childhood Education and Care (ECEC);
- Creating new, innovative or joint curricula or courses.

The project results were published on the website <https://kidslab-4sustainability.eu/> and on the Erasmus Plus Results Platform: <https://erasmus-plus.ec.europa.eu/projects/search/details/2021-1-PL01-KA220-SCH-000034345>, available in five languages: English, Spanish, Catalan, Polish, and Italian.

In the final evaluation, the project *Kids Lab for Sustainability* was recognized as an example of good practice.

Abstract

For many European Union Member States, early childhood education and care (ECEC) is becoming a top priority (Vandenbroeck, Lenaerts & Beblavy, 2018). ECEC refers to all arrangements for children from birth to compulsory school age, which varies across the EU. It includes day care and family care, funded from both private and public sources. Such care may be provided by daycare providers, childcare facilities (e.g. nurseries), and kindergartens (Council, 2019/C 189, 02; Surma et al., 2019). Numerous studies confirm that highquality education and care at this stage lay the foundation for later success in education and wellbeing, and support better integration. In the long run, therefore, ECEC yields economic, social, educational, and developmental benefits for society as a whole.

ECEC is also central to the implementation of the first principle of the European Pillar of Social Rights (European Pillar of Social Rights in 20 Principles, 2023) on equal opportunities in education, training, and lifelong learning. The document states that:

Everyone has the right to quality and inclusive education, training and lifelong learning in order to maintain and acquire skills that enable them to participate fully in society and manage successful transitions in the labour market (EPoS, 2023, No. 01),

and “Children have the right to affordable early childhood education and care of good quality” (EPoS, 2023, No. 11).

Highquality early care and education address, among other things, one of the most important educational goals: developing children’s intellectual aptitude for learning. Research shows that in the case of young children, this predisposition can be considered innate, as preschoolers naturally explore their environment, trying to understand the world through their own

actions, sensory experiences, and questions. In this way, they seek to understand how and why the world works. Unfortunately, many European preschools place excessive emphasis on formal academic learning (teaching reading, writing, and arithmetic) instead of nurturing children's predisposition to "learn how to learn".

In line with the Council Recommendation on Key Competences for Lifelong Learning (Council, 2018) and the European Pillar of Social Rights (EPoSR, 2023), the goal of the Kids Lab for Sustainability project was to improve the quality of ECEC programs by offering an innovative curriculum based on outdoor education, STEAM approaches, and sustainability. An added value of this curriculum is the creation of links between two key challenges identified in European Union documents: sustainable development as a source of educational content, and the STEAM approach as a methodology for teaching and learning.

The STEAM approach in early childhood education can be defined as a holistic, inquirybased strategy that involves children in solving complex, interdisciplinary, realworld problems in contexts that are meaningful to them. This approach can strengthen children's selfconfidence, develop their sense of selfefficacy and build a positive selfimage as learners. They also acquire a range of 21stcentury competencies.

Our project sought to transform teachers' approaches to early childhood care and education. The emphasis, therefore, was placed on developing children's intellectual abilities—such as critical and creative thinking, observing, predicting, comparing, drawing evidencebased conclusions, and reflecting on their own knowledge—rather than on the direct acquisition of literacy or numeracy skills. The STEAM strategy assumes that skills such as reading, writing, counting, and measuring become tools of thought, mental habits, and means of creating a culture of collaborative learning in preschool groups.

Research demonstrates that early STEAM education not only develops interest in science among preschool children but is also a key factor in preventing or reducing mathematics anxiety, as well as supporting personality development, social skills, resilience to failure, and emotional coping. This makes it a particularly valuable approach for narrowing gender gaps in science and technology professions and for promoting

equal educational opportunities. Through scientific experiments, observations, and research conducted in their immediate outdoor preschool environment, children can also be introduced to issues of sustainability.

In developing the new curriculum, the project team placed emphasis on raising both children's and teachers' awareness of environmental challenges and climate change—including the need to conserve resources, reduce energy consumption, adopt sustainable consumption habits in daily life, and build harmony between technology and nature to promote wellbeing. The concept of sustainable development formed the basis of our project, which became an inspiration for the international project team to develop practical resources for teachers (curriculum, lesson scenarios, and a methodological guide). It was also important to build awareness of the interconnections between the three pillars of sustainability: environmental, social, and economic. Helping children discover these links is intended to deepen their understanding of why the principle that *no one should be left behind* has been defined as a common foundation for the future green transition.

The 17 Sustainable Development Goals set out in the 2030 Agenda (UN, 2015) were incorporated into the new preschool curriculum developed by the project team, entitled *Kids Lab for Sustainability*. One of the aims of the programme is to support children in discovering and appreciating the connection between the Earth's resources and human wellbeing. The report consists of an introduction, four chapters, and a section describing the social impact of the results developed by our team.

The first chapter, Description of the Kids Lab for Sustainability project, outlines the principles of sustainable development, the project's objectives, and the methodology and procedures used in the evaluation research. The following three chapters present results based on diagnostic and action research conducted by the project team. Their purpose is to set out the theoretical and practical foundations of the Kids Lab for Sustainability project and to share selected research findings in the form of teaching and methodological materials.

The second chapter, entitled Repository of Educational Activities in the Field of Sustainable Development—Research Results and Effects

presents the results of pilot studies conducted with teachers and introduces two key outputs: Learning Activities, which include lesson plans developed by the project team, and the Learning Community and Learning Pathways. The third chapter, *Preschool Curriculum “STEAM Outdoor Activities for Sustainable Development” – Research Results and Effects* provides a handbook for preschool teachers in two parts. The first is the Theoretical Framework of the Preschool Curriculum; the second consists of methodological Guidelines for Teachers. This chapter also reports the results of an evaluation of the proposed preschool curriculum, conducted by teachers working with children and their parents.

Chapter Four, *Curriculum for Preschool Teacher Education*, proposes ways to enrich the educational offer for higher education and teacher-training centres. It puts forward recommendations for decisionmakers, which summarise the research findings from the entire project. One chief proposal was to support the training of future teachers. Accordingly, two documents are presented in the following subsections: (1) the *Curriculum framework for an academic course: STEAM in education for sustainable development*; (2) *Training manual for academic teachers*. The final project output was the development of an Online Course for Educators, the last subsection of this chapter which describes its structure, objectives, and participants’ views on the role of teachers in education for sustainable development and the challenges of outdoor education.

Since the project as a whole addressed topics such as sustainable development, STEAM education, and outdoor education—which were developed as separate yet complementary resources—some content may appear in more than one chapter. The project team sought to ensure that these themes were further elaborated in each subsequent section and adapted to different contexts.

The conclusion presents the results of implementation and the social impact of the project.

Introduction

The *Kids Lab for Sustainability* project corresponds to one of the Erasmus Plus horizontal priorities—Environment and Combating Climate Change—in combination with two priorities from the School Education sector. The first was defined as creating highquality education and care systems (ECEC) for preschool children, and the second as promoting interest and excellence in science, technology, engineering, and mathematics (STEM) and the arts, adopting a STEAM approach.

The theoretical foundations of our project refer to the 2015 guidelines of the United Nations General Assembly in the *2030 Agenda for Sustainable Development* (UN, 2015), which identify highquality education as one of the 17 Sustainable Development Goals (United Nations Educational, Scientific and Cultural Organisation [UNESCO], 2017). These documents emphasise that quality education the only possible way to achieve the other goals of a sustainable future. Preparing citizens to live informed lives in a rapidly changing world requires continuous acquisition and dissemination of knowledge. Quality education is therefore the responsibility of many social institutions, which must adapt to the changes taking place (Mróz & Ocetkiewicz, 2019).

It is increasingly recognised that climate change and environmental degradation pose existential threats to future generations. To combat these, the European Commission introduced the *European Green Deal* (2019), a strategy to make the EU economy sustainable, resourceefficient, competitive, and social. Although education may have limited direct impact on economic measures such as industrial decarbonisation, sustainable use and conservation of water, or pollution control, it plays an indirect yet vital role in the green transition by shaping simple, sustainable habits in future generations. Creating a sustainable world requires greater involvement of individuals as agents of change. To

fulfil this role, they must receive appropriate education—knowledge, values, skills, and attitudes—that will contribute to more sustainable development (UNESCO, 2017).

The education of young children must therefore adopt the principles of sustainable development. However, developing children’s key competencies in this area is only possible if teachers themselves possess the necessary knowledge. Thus, reform in education is needed at all levels, especially in the training of future teachers and in continuing professional development (Bertschy, Künzli & Lehmann, 2013).

Improving the quality of education systems in the *Kids Lab for Sustainability* project takes into account three closely interrelated levels: pre-school, higher education, and continuing education. It was implemented through:

- diagnosing the needs of teachers, students, children and their parents, as well as assessing the effects of implementing education for sustainable development at each stage of the project;
- designing a modern curriculum for preschool education that combines the STEAM approach and outdoor education with sustainable development;
- developing a core curriculum for preschool teacher training; and
- creating an online course to prepare students of preschool and early school education, as well as practicing teachers, for the practical implementation of the *Kids Lab for Sustainability* program as part of their professional development.

According to the *European Skills Agenda* (2021), in order to fully and consciously participate in social life, individuals must possess a minimum level of basic skills, including mathematical reasoning, reading and writing, and basic digital competencies. It is also essential to develop learners’ abilities related to sustainable living and making informed career choices in the future. The development of ecological attitudes and consumption habits should begin as early as preschool education. These activities should be based on providing scientific knowledge that underpins a sustainable lifestyle—by fostering skills such as conducting simple experiments, understanding and appreciating chemical and physical processes designed by nature (e.g. plants,

soil, atmosphere), and reasoning and drawing conclusions based on observed results from children's own actions. This understanding of education for sustainable development aligns with the STEAM approach, which holistically supports children in acquiring scientific competencies. Therefore, our project integrates education for sustainable development with the STEAM methodology, which, through inquiry-based learning, helps children develop an understanding of ecological footprint and the human impact on preserving or degrading nature—for example, through activities such as supporting biodiversity in preschool gardens, building bee hotels, observing the cycle of organic food production, and setting up compost bins.

This understanding of education for sustainability aligns with the STEAM approach, which holistically supports children in acquiring scientific competences. Therefore, our project combines education for sustainability with the STEAM methodology, which, through inquiry-based learning, develops children's understanding of the ecological footprint and human impact on the preservation or degradation of nature. Examples include activities such as enhancing biodiversity in preschool gardens, building bee houses, observing the organic food production cycle, and setting up compost piles.

High-quality care and education at the preschool stage are closely linked to the development of teachers' competence and confidence in applying inquiry-based approaches at the ECEC level (Surma, 2021). This is supported by the findings of the *CoRe: Competence Requirements in Early Childhood Education and Care* study (European Commission: Directorate-General for Education, Youth, Sport and Culture, 2011). The professionalisation of pre-service teachers is crucial to the teaching process, as it enriches interactions between teachers and children. Within the framework of the Kids Lab for Sustainability project, the activities undertaken and results achieved focused on developing relevant instructional and methodological materials aimed at supporting the professional growth of teachers in introducing the STEAM approach to working with preschool children and improving their practice.

Raising teachers' awareness that the concept of STEAM education emphasises the need to prepare the younger generation to solve

complex, interdisciplinary problems became central to our efforts. After all, a child achieves intellectual autonomy only when they have the opportunity to ask questions, observe natural physical and chemical phenomena, explore, and experiment. STEAM education is defined as an instructional strategy based on an interdisciplinary approach to life-long learning. It is grounded in the real, meaningful context of everyday problems. It aims to strengthen children's interest in science and their passion for learning, while instilling a sense of self-efficacy and resilience in dealing with stress, obstacles, and mistakes, which are natural elements of any educational experience (Zdybel, 2021). It also seeks to prepare young researchers and explorers for future careers in science, technology, or engineering (Plebańska & Trojańska, 2018).

The synthesis of Education for Sustainability with the STEAM approach in the *Kids Lab for Sustainability* project resulted from earlier international collaboration among partners from Poland (UIK), Italy (FPM and LUMSA), Ireland (DCU), and Spain/Catalonia (UIC) as part of the *Kitchen Lab for Kids* project, implemented from 2018 to 2021. That initiative aimed to gather best pedagogical practices and develop a methodological toolkit (manual and guidelines) for STEM education in early childhood (Szewczuk, 2021). *Kids Lab for Sustainability* complements the *Kitchen Lab for Kids* project, which focused on preschool education in indoor settings, especially the opportunities that the preschool kitchen provides as a science laboratory. These include exploring food ingredients, understanding the science behind food processing, and using technical tools available in any kitchen.

Kids Lab for Sustainability brings STEAM ideas outdoors, promoting a new approach built on the experience of forest kindergartens and the Montessori method, especially the principles of space education that Maria Montessori developed. In a sense, *Kids Lab for Sustainability* also draws on experiences promoted by the Boy Scouts, which seem to be forgotten or undervalued in modern society. It is important to link the ideas of STEAM education with the principles of education for sustainability (UN Decade, 2005).

STEAM education for sustainability in an outdoor environment—such as a garden, forest, or park, rather than only indoors in a preschool

building (Quay & Seaman, 2013)—applies the principle of learning in and about nature. It aims to develop an understanding of the ecological footprint and the impact of human behaviour on both the protection and degradation of the Earth’s natural resources. Through a variety of activities, the project promotes the formation of environmental habits and awareness that small, daily choices made by individuals can either harm or help preserve nature. In order to increase environmental awareness, everyone involved in the project focused on cultivating mindfulness in everyday life, and its development in children, by proposing simple relaxation exercises in outdoor settings, incorporating artistic activities into lesson plans, and helping children understand how nature supports both physical and mental health. These efforts resulted in a series of lesson plans and educational pathways for children.

It should be noted at this point that most existing STEAM education projects have placed a strong emphasis on promoting Technology (T) and Engineering (E), aimed at developing technological and digital competencies, while often overlooking the other components: Science (S), Arts (A), and Mathematics (M). Consequently, these initiatives have tended to target elementary school students and their teachers. In contrast, the two projects referenced above—*Kids Lab for Sustainability* and *Kitchen Lab for Kids*—adapt the STEAM approach to the capabilities and developmental needs of children under the age of six. Integrating all five STEAM disciplines into early learning experiences, starting with the exploration of scientific and natural phenomena, and incorporating the arts, provides an opportunity for children to construct knowledge and learn.

This approach is based on the assumption that young children possess the capacity for self-regulated learning and metacognitive reflection on their own knowledge. Research shows that these abilities are often undervalued in preschool education and are frequently perceived as too advanced or beyond young children’s reach—something we aimed to challenge through a series of long-term project activities (Pulak & Szczotka, 2019). The project presented in this report expands and deepens the content and methods related to the development of STEAM competencies in children, while aiming to strengthen executive

functions, scientific thinking, and teamwork skills. Its innovative character lies in introducing the concept of sustainability into everyday preschool practice: through new teaching materials for educators (*Repository of Sustainability Learning Activities* and the preschool curriculum *Outdoor STEAM for Sustainability*) and a dedicated online platform (<https://kidslab4sustainability.eu/>), which includes a self-paced online learning course for teachers.

Our goal has been—and continues to be—to support preschool teachers not only in understanding sustainability, but also in evaluating available resources and creating their own materials with the help of guidelines developed by an international community of researchers and educators. In order to enable teachers to gain both competence and practical experience in integrating the concept of green transformation into preschool practice, all developed materials (project outputs) were empirically validated in a cross-cultural context.

The innovative approach of the project centred on building a Learning Community composed of early childhood education students, preschool teachers, school administrators, and university researchers. This diverse group facilitated the exchange of good practices in STEAM education for sustainable development. The project's rationale was to support active learning (learning by doing and exploration) for both preschool children and their educators, and to motivate teachers to develop and apply modern, interactive methods for effective STEAM instruction.

The Learning Community activities that we introduced, along with the recommendations that we formulated, are designed to raise awareness among those responsible for early childhood education about the urgent need for change: from a traditional behavioural and passive model to a new approach centered on active, self-regulated, and independent learning through exploration of the natural environment.

The diverse actions proposed by our project team, resulting in the developed outcomes, aim to prepare the youngest generation to care for our planet—in line with the European Union's commitment to transitioning towards a sustainable economy in Europe (UN, 2015), where people “live well within the limits of our planet” (Latoszek, 2017).

Chapter 1

Description of the *Kids Lab for Sustainability* project

The *Kids Lab for Sustainability* project was developed in response to research findings gathered from teachers during the earlier *Kitchen Lab for Kids* project (Surma et al., 2019; *Teachers about STEM Education on the Preschool Level*, 2020), as well as the European Union's guidelines for ECEC (Early Childhood Education and Care). The initiative was carried out by a consortium of research institutions from Poland, Spain, Ireland, and Italy.

The project was led by the Ignatianum Foundation (Poland), in close cooperation with the Ignatianum University in Cracow (UIK). The international partners included:

- Universitat Internacional de Catalunya (UIC, Spain/Catalonia).
- Dublin City University (DCU, Ireland),
- Fondazione Politecnico di Milano (FPM, Italy),
- Libera Università Maria Santissima Assunta (LUMSA, Italy),

The aim of the project was to develop innovative educational solutions addressing the needs of various stakeholder groups: teachers, education students, children, parents, and educational institutions. Special emphasis was placed on enhancing teachers' competencies in STEAM education, sustainable development, and outdoor learning.

Diagnosis of needs and challenges

The project began with an ex-ante evaluation designed to identify the needs of preschool teachers in the areas of STEAM education, sustainability, and outdoor learning. Although these concepts are well established in academic literature, they remain insufficiently reflected

in educational practice, particularly at the early childhood education and care (ECEC) level.

An analysis of curricula and educational frameworks in the partner countries revealed that both STEAM and sustainability topics are underrepresented in preschool education and in the training of future teachers. Research conducted among teachers in four countries revealed several common barriers:

- Lack of adequate professional preparation: ECEC studies are often overly theoretical or too general.
- Lack of resources: Teachers reported shortages of equipment and funding, which force them to purchase materials themselves.
- Lack of institutional support: Teachers who wish to implement innovative practices frequently face resistance from colleagues and school leadership, which can lead to professional burnout (*Teachers about STEM Education on the Preschool Level*, 2020).

Such obstacles and challenges can be overcome at the intercultural level by providing a shared platform for methodological and emotional support, in which teachers can observe the work of peers from other countries, exchange ideas, draw inspiration, and more. Despite the differences described, there is one important similarity: all teachers surveyed recognised the urgent need to introduce STEAM into preschool education in their countries. Our project responds to the needs reported by pre-service and early childhood education students and teachers for acquiring professional, social, and personal skills suited to the challenges of the modern world. It also responds to new challenges that emerged in the context of the COVID-19 pandemic, particularly the strong need to build and rebuild relationships and to promote the idea of cooperation in different communities.

The project also takes into account the need for children to participate in engaging outdoor learning activities. By offering creative solutions to teachers and encouraging them to conduct experiments, observations, and challenges with children based on the idea of STEAM, children can gradually and systematically build and expand their general knowledge, acquire new skills, gain new experiences, and learn about their immediate environment. The project also considered the needs

of partners from four countries. Although each partner had different experiences and competencies related to STEAM, sustainable development, and outdoor education, they were all highly motivated to develop and implement new ideas in preschool education in their countries. Consequently, they also aimed to prepare highly competent teachers capable of combining sustainability with STEAM approaches in the learning process of young children.

Since the idea of outdoor STEAM education for sustainable development is perceived and implemented differently across EU countries, international cooperation in the implementation of the project proved extremely important for promoting cross-cultural exchange of good practices, as well as sharing experiences and learning methods. This process allowed all parties involved to better understand and appreciate cultural diversity—a factor that enriches culture and society.

Each partner contributed a distinct set of strengths in terms of human resources, expertise, and facilities to the project.

DCU (Dublin City University) brought a high level of expertise in STEM education. It was the only partner with a dedicated teaching department for the field: the *School of STEM Education, Innovation and Global Studies*. In addition, DCU publishes a journal related to innovation in education (*International Journal for Transformative Research*, Online ISSN 2332-3736).

As a strategic partner, FPM (Fondazione Politecnico di Milano) contributed its expertise in developing multidisciplinary innovation projects related to lifelong learning, digital learning, networking, and technology transfer, which are fundamental to building a knowledge-based economy, supporting the green transition, and promoting innovative organisational and professional change. One of FPM's key strategic missions is to raise awareness of STEAM among young people, in line with the competencies taught at Politecnico di Milano University.

The rapid development of new technologies in the field of education, which is one of the few positive outcomes of the COVID-19 pandemic, has generated new challenges in the preparation of teaching materials and resources. These materials must be coherent, transparent, and easy to use. As a partner with extensive experience in digital teaching

and learning, FPM ensured that the final product meets the highest standards of quality.

LUMSA (Libera Università Maria Santissima Assunta) contributed its expertise in ECEC education, with a particular focus on shaping young children's competencies, building cooperation between kindergartens, schools, and families, supporting the development of basic skills in children aged 0 to 6, and evaluating educational processes, communication, and the creation of audiovisual materials in university education.

The Atlante Montessori platform (<https://www.atlantemontessori.org/it/>) developed by the university was helpful in shaping the content of the teaching materials. Historical materials on the principles of the Montessori method, particularly the concept of cosmic education, provided a comprehensive theoretical and didactic foundation for the *Kids Lab for Sustainability* project, especially in terms of supporting education for peace and human well-being.

UIC (Universitat Internacional de Catalunya) brought extensive experience in education for sustainable development based on a Christian perspective on the stewardship of Earth's natural resources (<https://www.uic.es/ca/recerca/recerca/grups-de-recerca/ciencies-socials-i-juridiques/grc-sostenibilitat-i-educacio>), as well as strong training and methodological expertise.

The university provides training for ECEC teachers (Fuertes et al., 2019) in educational approaches that act as a positive driving force for social change, particularly through the EDINSOST initiative (Education and Social Innovation for Sustainable Development). UIC promotes the development of sustainability-related competencies among educators (Tejedor et al., 2019) and specialises in designing methodological tools that support teachers in cultivating sustainable teaching practices (Albareda-Tiana et al., 2019).

IF (Ignatianum Foundation) combines all the above-mentioned areas of interest and is a reliable and experienced public benefit organisation working with stakeholders and decision-makers in the educational sector. IF brought both organisational and training expertise

and, as project coordinator, contributed to the implementation of all activities in cooperation with Ignatianum University in Cracow.

Thanks to the collaboration among organisations with specific and complementary expertise, and through the continuous exchange of ideas and best practices, the partners and staff involved in the project benefited from enhanced cooperation, a shared understanding of strategies for sustainability education, and increased intercultural awareness. This synergy facilitated the resolution of common problems and supported the planning of future collaborative projects.

This chapter outlines the conceptual pillars of sustainable development, the project's objectives and priorities, and the methodological assumptions and evaluation procedures.

1.1. Theoretical assumptions of the project: The concept of sustainable development

Although the concept of sustainable development is not new, it still requires actions aimed at achieving goals on a global, international, national, regional, and local scale. Its ideas began to take shape as early as the 1960s, when the ecological movement started to develop, interest in nature conservation increased, and ecology as a science—studying the relationships between organisms and their environment—began to grow dynamically (Rokicka & Woźniak, 2016).

The term *oekologie* (ecology) was first coined by the German zoologist Ernst Haeckel in the second half of the 19th century. It derives from two Greek words: οἶκος (*oikos*)—meaning household, home, or place of living—and λόγος (*logos*)—meaning word or science (Pimm & Smith, 2025).

The natural environment has played a crucial role in the life and functioning of humans and other organisms since the beginning of human existence. However, civilizational changes, industrial development, and urbanization in the 20th century significantly contributed to ecological disasters, which necessitated a shift in human attitudes toward the environment.

In response to these challenges, the concept of *ecodevelopment* was introduced into global discourse during the international conference in Stockholm in 1972 (Kozłowski, 1996; Wójtowicz, 2010). This concept can be seen as one aspect of sustainable development, although it is sometimes treated as its synonym. Both concepts emphasize the responsibility to protect the environment for future generations. However, *ecodevelopment* has a narrower scope than *sustainable development*.

This conference marked the beginning of the environmental education movement. Also significant in shaping education for sustainable development were the UN Secretary General Sithu U Thant's report *Man and the Environment* (1969), and the *Our Common Future* report compiled by the Brundtland Commission (1987), led by Gro Harlem Brundtland. This report made the first attempt to define the concept of sustainable development (SD), explaining it as follows: "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, No. 27).

This concept is currently defined in various ways. Justice Mensah (2019), based on a systematic literature review, analyses its meaning. One approach is a literal interpretation, according to which sustainable development means "the ability to maintain a unit, outcome, or process over time" (Basiago, 1999). This definition focuses on the durability of development as both a process and a result. Other researchers (Milne & Gray, 2013; Tjarve & Zemīte, 2016; Mensah & Enu-Kwesi, 2018; Thomas, 2015) expand its meaning, indicating that sustainable development is a concept referring to the improvement and maintenance of a healthy economic, ecological, and social system that serves human development (Mensah, 2019, p. 5). The term can also be understood as "giving priority to the needs of all forms of life and the planet by ensuring that human activity does not exceed planetary boundaries" (Bianchi, Pisiotis & Cabrera Giraldez, 2022, p. 15). Another definition states that sustainable development is "the efficient and fair distribution of resources both within and between generations, while conducting socio-economic activities within the limits of a finite ecosystem" (Stoddart, 2011; Mensah, 2019, p. 5).

In Polish literature, Józefa Bałachowicz proposes a definition of sustainable development that takes into account its pedagogical and moral dimensions. The author points out that:

Sustainable development is primarily about the relationship between people—generations living today and those yet to come—and the relationship between humans and their living environment. This interpretation has a deeply moral and pedagogical dimension, as it touches the core of pedagogical thinking and action, which is the service of inter- and intra-generational integration, care for the living environment, and support for successful human development. (Bałachowicz, 2017, p. 24)

A comparison of selected definitions of sustainable development reveals a number of common elements as well as significant differences in their interpretation. Most of the analysed definitions include both intergenerational and intragenerational aspects, refer to ecological issues and social responsibility, and emphasize the importance of durability and balance between needs and available resources. The differences mainly concern the scope and level of detail in understanding the concept—ranging from general, technical interpretations (e.g., Basiago, 1999), to more complex and systemic approaches (e.g., Mensah, 2019; Stoddart, 2011), and definitions that incorporate moral and pedagogical dimensions (Bałachowicz, 2017). These concepts also highlight two distinct perspectives: some adopt an anthropocentric approach, focusing on human needs, while others represent an ecocentric view, emphasizing the primacy of environmental protection and all forms of life. In our project, we refer to the definition of sustainable development understood as a broadly defined process of shaping a balance between the needs of present and future generations, carried out within the limits of the natural environment through the implementation of educational and social activities.

Since our target group consists of preschool children, we focus on education for sustainable development that incorporates the STEAM approach, supporting the development of scientific, ecological, and social competencies. We also take into account the moral (ethical) and

pedagogical dimensions. At the same time, implementing interdisciplinary education among adults—teachers, parents, and caregivers—was essential for us, as they play a key role in creating an environment that supports child development, respects the needs of others, and follows the principles of sustainable living.

In the project, we also refer to the three pillars of sustainable development, which include: ecological sustainability (environmental pillar), economic development (economic pillar), and social justice—both between generations and within each generation (social or socio-cultural pillar).

The environmental pillar emphasizes the need to preserve the integrity of ecosystems and the capacity of the natural environment to sustainably support human life. It focuses on protecting natural resources (water, air, soil), maintaining biodiversity, and reducing the negative impact of human activity on the planet. The economic pillar assumes economic growth based on responsible management of natural resources, so as to meet the needs of the present generation (in terms of consumption levels) without compromising the needs of future generations (Lobo, Pietriga & Appert, 2015). The social pillar refers to values such as equality, agency, accessibility, participation, and cultural identity (Mensah, 2019). It involves creating conditions that support human well-being and the fulfilment of basic needs, with particular attention to combating poverty and ensuring universal access to education and healthcare. The principles of sustainable development are systemic in nature, and their effective implementation requires both top-down actions—at the level of policies and strategies—and bottom-up initiatives involving society, educational institutions, and local communities. Our project is one example of such initiatives, and it also aligns with the Sustainable Development Goals announced by the United Nations (2015).

Countries that have signed the declaration are obliged to pursue the Sustainable Development Goals (SDGs), announced by the United Nations in 2015. Achieving these goals, which is targeted for 2030, requires the implementation of effective education that:

- enables learners to acquire the skills, knowledge, and values which are essential for sustainable development;
- is equally accessible at all levels and in all social contexts (family, school, workplace, local community);
- fosters civic responsibility and promotes democracy by raising awareness of individual rights and responsibilities;
- is grounded in the principle of lifelong learning;
- promotes the balanced development of the individual.

Education for sustainable development is expected to equip learners with a broad set of skills, especially creative and critical thinking, effective communication, conflict resolution, and the ability to design strategies for problem-solving. It should also instil in children and students a respect for planet Earth and life in all its diversity (UN Decade, 2005). Such education is also intended to prepare learners to promote democracy, tolerance, and peace. As Aleksandra Kuzior notes, these are “not utopian goals, but ones that can be achieved through the involvement of various social actors, institutions, organisations, civil society, and the media in building awareness of sustainable development, based, among other things, on reliable, consistent, and factual information about the concept” (Kuzior, 2014, p. 4).

Education for sustainable development should be understood as an integral part of quality education and lifelong learning. In practice, it goes beyond ecological or environmental education. It is a multidisciplinary approach that offers each person, in different educational contexts and at various stages of life, the opportunity to learn a way of living that supports both personal well-being and sustainable development, while preserving environmental resources for future generations.

All institutions, from kindergartens to universities, should take responsibility for implementing the principles of education for sustainable development. This form of education is intended to support a range of cross-cutting competencies which reflect the need for transformation in the educational process. These competencies include systems thinking, critical thinking, exploratory thinking, problem formulation, self-awareness, normative thinking, strategic thinking, collective action, future

thinking, adaptability, complex problem-solving, and the capacity for individual initiative (Bianchi, Pisiotis & Cabrera Giraldez, 2022, p. 18).

Education for sustainable development is part of the trend of transforming education systems from knowledge-based models to competency-based approaches—a shift that began in the early 21st century. Sustainability competencies are designed to empower learners to embody the values of sustainability in their attitudes, understand complex systems, and take action to restore or maintain healthy ecosystems, while promoting equity for a sustainable future (Bianchi, Pisiotis & Cabrera Giraldez, 2022).

In line with the belief that even young children can learn that humans are part of and dependent on nature, we focused on developing an innovative preschool curriculum. This includes activities that introduce concepts such as the human-nature relationship, the impact of human behaviour on ecosystems, and the importance of conserving resources for future generations. These are just some aspects of knowledge, skills, and attitudes that are fundamental to the well-being of both individuals and society.

1.2. Priorities and goals of the *Kids Lab for Sustainability* project

The goals of the project were closely related to three key priorities set out in the Erasmus Plus program:

1. Environment and fight against climate change (Horizontal priority);
2. Developing high quality early childhood and care systems (sectoral priority);
3. Promoting interest and excellence in science, technology, engineering, and mathematics (STEM), along with the integration of STEAM approaches (sectoral priority).

The main objective was to promote the development of sustainable attitudes in preschool children by first influencing and transforming teachers' mindsets.

The project addressed three key areas:

- expanding knowledge about sustainable lifestyles;
- promoting sustainable behaviour and daily choices, and
- cultivating sustainable awareness to help children become agents of change in their own families.

Our efforts also focused on improving the quality of education at the ECEC level, which required the active participation of pre-service teachers, university faculty, and students preparing to become educators. Helping these groups understand the importance of connecting classroom learning with the real world was key to helping children discover the relationship between human well-being and the natural environment. An important shift in adult attitudes should involve encouraging children to investigate scientific concepts in the context of the external environment and to carry out technological and engineering experiments that can help them understand how a modern, sustainable economy can operate locally.

These goals are detailed below and linked to the planned project results:

1. Improving the quality of preschool education by:
 - conducting surveys among teachers and analysing the results,
 - developing a compendium (available on the project platform <https://kidslab4sustainability.eu/focus-on/>);
 - developing the *Preschool Curriculum “Outdoor STEAM for sustainability”* (<https://kidslab4sustainability.eu/preschool-curriculum/#PreschoolCurriculum>) which consists of two manuals: *Theoretical framework* (<https://kidslab4sustainability.eu/theoretical-framework/>) and *Guidelines for teachers* (<https://kidslab4sustainability.eu/guidelines-for-teachers/#p1>)
2. Enhancing preschool teachers’ sustainability competence (and confidence) by providing a set of innovative teaching materials that combine sustainability concepts with STEAM methodology
 - Repository: *Learning activities* <https://kidslab4sustainability.eu/teaching-set-introduction/#areas> and *Learning pathways* <https://kidslab4sustainability.eu/learning-pathways/>
3. Building synergies and facilitating knowledge exchange between universities, preschools and education policymakers to ensure greater

- impact on local preschool systems through the development of *Recommendations for policy makers* (<https://kidslab4sustainability.eu/recommendations-for-policy-makers/>).
4. Educating “leaders of change”—pre-service teachers—to promote the STEAM approach to sustainability education through the development of an *Online course for educators* (<https://kidslab4sustainability.eu/online-course-for-educators/>) available in English on the *Kidslab4sustainability* project website and on the *navoica.pl* platform (versions in English, Polish, Spanish, and Italian).
 5. Improving the quality of academic education in ECEC by developing a *Curriculum framework for an academic course: STEAM in education for sustainable development* (<https://kidslab4sustainability.eu/curriculum-for-preservice/>) and a *Training manual for academic teachers* (<https://kidslab4sustainability.eu/results/manual/#Manual>).

1.3. Methodological framework and evaluation research procedure

The development and implementation of educational activities in practice required a series of diagnostic studies with an evaluative focus. We assumed that evaluation involves assessing (Oxford English Dictionary, 2002) the value of a project in terms of its effectiveness, efficiency, relevance, and sustainability, using research methods from the social sciences to improve, refine, and better understand it. This corresponds to the widely recognised concepts of *formative evaluation* and *summative evaluation*, introduced by Michael Scriven in 1967 (Scriven, 1967; see Boratyńska-Karpiej, 2020).

The evaluation in our project aimed to determine whether our intended goals were achieved and which factors contributed to—or hindered—success. We sought to identify cause-and-effect relationships between specific actions and their outcomes. Our research approach was theory-based and designed to explain and assess both the process of generating impact and the extent and achievement of results (i.e., what impact occurred and why).

We planned and conducted four types of evaluation:

1. Initial evaluation (*ex-ante*),
2. Ongoing evaluation,
3. Mid-term evaluation,
4. Final evaluation (*ex-post*).

The first evaluation focused on identifying teachers' needs in education for sustainable development and outdoor education through focus group interviews. Understanding these needs was crucial for assessing the relevance of our planned activities.

The objectives of this study were to explore:

- teachers' opinions and needs in two areas: education for sustainable development and outdoor education,
- teachers' knowledge of the interconnections between STEAM educational experiences and outdoor education for sustainable development.

After establishing the objectives, a list of prompts was prepared to support the development of a focus group interview aimed at gathering participants' opinions on education for sustainable development, outdoor education, and the STEAM approach. We investigated the following categories: knowledge (associative explanations and definitions of both approaches); theory and practice (current implementation status, opportunities for integration into practice, methods, forms, development of STEAM competencies in both approaches, challenges, and issues related to ESD and outdoor education); and professional development and prior preparation (existing training opportunities, further training needs, and suggestions for useful training).

The main research tool was a focus group interview script, which included a detailed plan for the meeting, instructions for the moderator, activation techniques, and a specified duration for each stage. The script consisted of seventeen questions developed based on the list of prompts. Among them were questions such as: *What comes to mind when you think about education for sustainable development? List the first five words that come to your mind.* Similar questions were

asked in the next stage of the study, which focused on outdoor education. During the focus group interview, participants also had the opportunity to respond to two short videos selected by the project team, presenting both educational concepts in practice. They were then asked to answer further questions, such as: *What connections do you see between the teaching practices shown in the video and your own teaching practice? How would you incorporate education for sustainable development/outdoor education into your own practice?* The remaining questions addressed needs, challenges, and training opportunities, in line with the list of prompts.

The interview was recorded, transcribed, and analysed using thematic codes based on the entries in the prompt list.

The results from this stage of the pilot study (*ex-ante* evaluation) are presented in section 2.1.

Based on data collected from preschool teachers in four EU countries, we assessed the relevance of our goals and the usefulness of the planned outputs. This diagnostic research underpinned the development of methodological materials that responded to teachers' needs and were published on the project website in the *Focus on* (<https://kidslab4sustainability.eu/focus-on/>) and *Repository* (<https://kidslab4sustainability.eu/repository-of-activities/>) sections.

The methodological materials developed, particularly lesson plans and educational pathways, were then evaluated by teachers and tested in practice. All partners invited kindergarten teachers, pre-service teachers, and academic staff to participate in a "learning community". Through workshops, this group gained practical knowledge of the principles of education for sustainable development, the STEAM approach, and outdoor education. Their task was to evaluate the teaching and methodological materials and, in the next stage, to pilot them with children in kindergartens.

The second type of research, involving ongoing evaluation, was conducted among teachers who, after implementing selected lesson plans with children and familiarizing themselves with the website (specifically the structure of the Repository) during workshops, completed an evaluation survey. The research tool was an online questionnaire

consisting of several open-ended questions (e.g., *What are the main advantages of the Repository? What are its disadvantages?*) and Likert scale questions. Participants were given the opportunity to assess the content offered in the Repository and in the Teacher Guidelines. In the first case, they rated—on a five-point scale—the originality of ideas, completeness of lesson plans, content, and educational pathways. In the second case, they were asked to respond to open-ended questions such as: *What changes would you like to introduce in the Teacher Guidelines? What other terms/concepts should be added to the glossary?* Members of the Learning Community also evaluated the lesson plans directly on the project website. A total of 136 lesson plans were rated using a ten-point scale.

The results are presented in section 2.3.

To verify the effectiveness of the proposed methodological materials, additional studies were conducted with parents and with the children who took part in the activities. The focus group interview method was also used with children. The research tool was a focus group interview script designed specifically for children, including instructions for the teacher, guiding questions, and coding schemes for evaluating responses. The instruction read: *“Ask the children to sit in a circle. The teacher takes a seat in the center of the circle. The following questions should be treated as guidelines. If, during the interview, children begin to talk about other relevant topics, it is worth continuing the conversation in that direction. The order of questions may be adjusted depending on the flow of the meeting.”*

The teacher received a script containing eight questions, such as:

Question 1 (Q1): *Did you have fun during our activities? What brought you the most joy?*

Question 2 (Q2): *What did you learn? Each child indicates three things they learned.*

Question 7 (Q7): *Do you think it is worthwhile to learn in nature and through contact with the natural environment?*

The interview analysis also included coding schemes for evaluating responses. For example: Q1 assessed the level of enjoyment and engagement during the pilot activities. According to play theory, if children

had fun, they were likely learning in a meaningful way. Q7 assessed the importance of outdoor education from the children's perspective.

To gather parents' opinions, an online questionnaire was prepared, containing both open-ended questions and Likert scale items. Parents were asked to evaluate, on a four-point scale, the development of their children's sustainable development skills.

The results of the pilot programme for kindergartens, implemented by teachers with children and their parents, are presented in section 3.3.

Analysis of the ongoing evaluation results for the first output led to revisions of the materials published on the project website, the expansion of the repository (including lesson plans and educational pathways developed by learning communities from four countries), and the creation of a teacher's handbook. This handbook consists of two parts and forms the next output: the *Preschool Curriculum: Outdoor STEAM for Sustainability*. The ongoing evaluation also allowed us to assess the relevance and effectiveness of the actions taken by all partners in producing didactic and methodological materials for teachers working with children, as well as training materials.

The next step was to develop and implement an online course for educators in English. As part of the ongoing evaluation, it was first reviewed by two experts and then, in a pilot phase, by early childhood education students and other participants. The evaluation of the course covered both technical aspects (website functionality, duration, accessibility) and practical aspects, such as opinions on content selection and structure, teaching methods, and communication. Participants in the pilot course evaluated it in terms of content (the extent to which the materials were consistent with the course topics), methodology (the extent to which methods, tasks, tests and other multimedia materials were consistent with the presented content, as well as whether they were useful, interactive and relevant to students' expectations) (Szewczuk, 2024).

The results of the online course evaluation in English informed revisions and supported the development and implementation of national-language versions, which were made available on the *navoica.pl* platform. Course participants were also asked to share their experiences

with the practical implementation of sustainable development and outdoor education. Comments posted by participants in the Kids Lab for Sustainability course were analysed according to several identified thematic categories. The results of this evaluation is presented in section 4.4.

To ensure the achievement of all project goals, internal periodic evaluations were also carried out to monitor the schedule, assess the effectiveness and efficiency of activities, and evaluate cooperation between partners. These results were discussed during project coordinator meetings. Upon project completion, a final evaluation was carried out to assess its overall value, verify the implementation of planned activities, and measure its social impact. The findings from the final evaluation, including achieved indicators and a description of the social impact, will be discussed in the conclusion of the report.

The content presented below is the outcome of work by an international team, arising from the need to improve the quality of preschool education and implement the principles of sustainable development.

Chapter 2

Repository of sustainability learning activities: Research results and effects

The first planned outcome was the creation of teaching materials for preschool teachers to support activities that combine sustainable development, outdoor education, and the STEAM approach. Between January and June 2022, the project team carried out a series of activities that culminated in the publication of the *Repository* on the Kids Lab 4 Sustainability project website. The repository consists of two sections: 1) Educational activities—a series of lesson plans organised by season and Earth sphere (biosphere, hydrosphere, geosphere, and atmosphere) 2) Learning paths—available at <https://kidslab4sustainability.eu/repository-of-activities/>.

The development of these teaching resources was preceded by diagnostic research, which identified the needs of preschool teachers. At this stage of the project, a brief introductory section was also prepared to explain key concepts. This was published in the *Focus On* section (<https://kidslab4sustainability.eu/focus-on/>) and includes a glossary defining selected terms mainly related to sustainable development (e.g., circular economy, recycling, upcycling, downcycling, climate justice, climate anxiety, carbon footprint, among others). It also provides short explanations of education for sustainable development, outdoor education, and the STEAM approach.

The DCU project team coordinated the preparation of this output. Teams from other universities conducted research, analysed the findings, developed resources, and designed the learning paths. FPM developed the project website and published the materials supplied by the partner teams in five languages.

This chapter presents the results of the pilot studies conducted as part of the initial evaluation, which formed the basis for developing preschool lesson plans and learning paths. Examples of selected lesson plans and one of the learning paths, evaluated by the Learning Community during the training cycle, are presented below. The results of the ongoing evaluation, assessing the training and the materials included in the repository, are presented at the end of this chapter.

2.1. Sustainable development and outdoor Education: Pilot study results

The development of teaching guidelines and methodological materials required pilot studies to gather the opinions of teachers from four different countries on sustainable development, outdoor education, and their connections to the STEAM approach. In each partner country, two focus group interviews were conducted with kindergarten teachers representing diverse professional tenures in both public and private institutions. Each group consisted of 8–9 participants. The questions asked to the teachers were developed based on the list of prompts and conducted according to the prepared focus group interview script. Participants were shown filmed examples of activities with children—both in education for sustainable development and in outdoor education—and were asked to evaluate and compare them with their own experiences.

The material collected from the focus group interviews was analysed by each research team according to pre-defined thematic categories and then presented to the other project partners. The results were compared, leading to the creation of a jointly developed set of guidelines for the repository comprising three resources:

1. focus on covering the most important introductory principles of education for sustainable development, outdoor education, and the STEAM approach;
2. lesson plans for children; and thematic
3. learning paths.

Education for Sustainable Development: Research results

The first category to emerge from the focus group research concerned participants' knowledge of education for sustainable development. Teachers were asked to provide their own explanations and definitions of sustainable development and to identify links between sustainable development and STEAM education. For teachers in all four countries, education for sustainable development was most commonly associated with concepts such as support, development, nature, integration, ecology, health, harmony, education, social relationships, citizenship, awareness, respect, experience, knowledge, play, conscience, will, engagement, logistics, open space, creation, recycling, and lifestyle. Based on these responses, the following graphic was produced, showing the most frequently cited associations (Fig. 1).

Fig. 1. Education for Sustainable Development—Association Cloud



Source: <https://kidslab4sustainability.eu/>

Because the term *sustainable development* is defined in various ways, participants often found it difficult to clearly articulate what it means. The concept was rarely associated with the economy, economic systems, or concern for the future—elements that represent the three pillars of sustainable development. This lack of reference to these pillars, especially the recognition of the interdependence and balance

between nature, society, and the economy, has also been noted in the literature (Rokicka & Woźniak, 2016, p. 10). This may stem from the difficulty of interpreting these interconnections and grasping the essence of the concept itself.

According to the Brundtland definition of sustainable development (1987), it involves “actions with long-term and significant social and economic impact that ensure present and future generations have living conditions that meet all their needs” (Marczak, 2015, p. 178). In our project, we paid particular attention to this definition when designing lesson plans and learning pathways.

Another challenge in interpreting the concept—highlighted both by our participants and by researchers (Forsyth, 2005; Sachs, 2005; see also Rokicka & Woźniak, 2016)—is understanding the term *development* itself. It may refer to changes taking place in the world (a descriptive meaning) or to what should happen (a normative meaning) (Rokicka & Woźniak, 2016). Also as a process or outcome of development (Basiago, 1999). In line with the 2030 Agenda for Sustainable Development (UN, 2015), current attention is focused on social development, economic growth, and environmental protection, with the aim of reducing inequality and injustice, eliminating hunger and poverty, and promoting the sustainable use of resources. A holistic approach to sustainable development should be incorporated into education at all levels.

The next set of questions focused on the practical application of education for sustainable development (ESD). After watching a video illustrating an example of such activities, participants shared their own experiences with implementing ESD and suggested ways to incorporate it into their everyday professional practice.

Analysis of the responses from Spanish teachers showed that their work with children mainly focuses on waste sorting through teamwork and incorporating recycled materials into activities. They view ESD as a structured process aimed at raising awareness among educators, who should serve as role models in promoting behaviours that minimise waste. In practice, this includes initiatives such as organising preschool breakfasts where children are encouraged to eat fruit—healthy and waste-free. The teachers also stressed the value of fostering respect

for nature through outdoor activities (e.g., forest visits), plant cultivation, and raising awareness about the need to care for the natural environment.

Polish teachers placed greater emphasis on the individual and social development of children. As they explained:

Basically, everything we do is to ensure the sustainable development of each child—preparing them for life and teaching them to care for the environment from an early age.

When children come to preschool, they must learn to function in a group, not think: “It’s just me and everything is for me.”

We make sure that children are sensitive—to each other and to the world around them.

These teachers also noted that they involve the entire preschool community, including parents, in various initiatives promoting both physical and mental health. They take action to protect the local environment in collaboration with other preschools and community organisations (e.g., animal welfare groups). They highlighted the importance of modelling positive behaviours and responding to current challenges such as the COVID-19 pandemic, allergies, and other health and environmental threats.

Italian teachers stressed the importance of instilling eco-friendly habits through everyday routines such as waste separation and reducing plastic use. They also underscored instilling respect for people, animals, and the environment. A significant part of their work focuses on teaching about sustainable nutrition.

Teachers from Ireland emphasised the importance of clearly defining the concept of sustainable development and described it as a process of support, not just instruction:

When it comes to sustainability and the natural environment, I like the idea of supporting rather than teaching and training. You support something that already exists and build on it, you know, in a positive way for everyone.

They also highlighted the importance of identifying opportunities, using appropriate language, modelling behaviours through play, and

encouraging child-led learning. One teacher underscored the value of developing normative competencies: “What struck me was the idea of fairness—something we do in our work with children, teaching them how to be fair to each other and to respect the things around them.”

Participants were then asked to suggest ways of putting the principles of education for sustainable development into practice. Analysis of their responses shows that their understanding of sustainable development directly translates into their classroom activities.

Spanish teachers reported that they develop ecological awareness through recycling and using waste materials. Preparing healthy breakfasts together and reducing waste encourages cooperation and community involvement. They also saw opportunities for collaboration with organisations promoting sustainable development. Education through hands-on experiences in nature—such as growing plants in the classroom or using the school garden—was also mentioned. In their view, a conscious, well-informed teacher plays a key role in shaping students’ attitudes.

Teachers in Italy proposed several interesting initiatives, including:

- Service learning: engaging in activities that benefit the local community, such as decorating streets during the holiday season.
- Local projects: strengthening connections to the local area and its cultural heritage.
- Twinning and eTwinning: international cooperation supported by new technologies.
- Learning by doing: cultivating curiosity and civic skills.
- Promoting a sustainable educational environment: for example, adopting a “Plastic-Free School” policy.
- Experiments and creative activities: learning through play and imagination, developing creativity and cause-and-effect thinking.

Polish teachers gave similar examples: participation in social campaigns (e.g., environmental initiatives), experiments, and providing children with the freedom to act independently, which builds responsibility. They also stressed cooperation with parents. Joint preschool initiatives might include healthy breakfasts or waste reduction projects.

Teachers from Ireland pointed to modelling, problem-solving, play, and observation as the most effective methods. They indicated that

teaching strategies should encourage creative thinking, and that observing children's actions while offering support, particularly in child-led learning, can be especially effective.

Although not all participants had a clear understanding of the concept of sustainable development, it can be concluded that they implemented selected aspects of it in practice, particularly those related to ecology, caring for nature, and participating in various local community initiatives. They were also familiar with a range of teaching methods, which they applied in their work. However, what was often missing from these initiatives was helping children understand the underlying purpose of the activities—especially how they connect to the three pillars of sustainable development and their interrelationships.

The next set of questions asked participants about their professional development and prior preparation for working in the field of education for sustainable development; methods for teaching STEAM skills in the context of sustainability education; and the challenges and issues associated with these approaches.

According to their responses, all participants had attended various training sessions. These included workshops on working in small groups, conducting experiments and scientific observations with children, leading workshops with children and parents, developing fine and gross motor skills, and teaching through hands-on experience and exploration. However, in Spain, participants noted a lack of formal courses on education for sustainable development, with training available only to schools within the Green School network. They did note, however, that a national committee on sustainable development provides recommendations that are implemented in educational institutions. In Poland, teachers reported that their university programs did not include such training, apart from mandatory civic education, and they had not participated in any training specifically devoted to education for sustainable development.

The participants also pointed out the need for integrating STEAM with education for sustainable development, designing educational environments that support children's agency, working with children in the context of crises (e.g., war, pandemic), collaborating with families on

education for sustainable development, and using modern technologies in preschool education.

Teachers also expressed the need to for:

- New ideas for presenting content in a simple and engaging way,
- Practical, hands-on experiences,
- Greater awareness of the teacher’s role,
- Opportunities to share experiences with other teachers.

When asked to provide examples of activities that develop STEAM skills in combination with education for sustainable development, participants mentioned:

- Experiments with apples, snow, and water: children learn to formulate hypotheses, which supports the development of scientific thinking.
- Building block towers and testing prototypes, which fosters spatial reasoning.
- Using magnifying glasses for observation, which encourages children to develop sensitivity to nature.
- Creating objects from recycled materials and designing their own tools, which enhances creativity and agency.
- Sorting, measuring, and classifying, which develops logical and mathematical thinking.
- Learning to use tools (scissors, needle, knife), which improves fine motor skills.

“A child already has a tool—their hands—so when we develop fine motor skills in preschool, the child will be able to manage later on.”

According to respondents, the biggest challenges and obstacles in translating theory into practice include:

- Curriculum: Lack of coherence and difficulty integrating ESD across subjects.
- Collaboration with staff: Limited shared responsibility among teachers.
- Parents: Resistance to “messy” activities (“A child needs to get dirty, and that’s completely natural, but parents don’t accept it.”).
- Children’s motivation: Preference for new technologies requires effort and adaptation from teachers.
- External factors: Pandemic, war, lifestyle diseases.

- Lack of adaptation: Unproven solutions or tasks that are too difficult.
- Equipment and finances: Limited resources, though low-cost activities are possible (“We tend to think money is needed to organise something, but it turns out that sometimes it’s not necessarily required—but then more willingness and work are needed.”).

Participants acknowledged the need to incorporate the concept of sustainable development more fully into their work with preschool children, although they also recognised that their knowledge in this area needs to be further developed. They were familiar with—and actively used—teaching methods that support the development of sustainability competencies through the STEAM approach. Some had previously taken part in another project run by our consortium (*Kitchen Lab for Kids*).

The challenges identified by the participants call for coordinated action at multiple levels, including individual institutions, governing bodies, and organisations responsible for education.

Outdoor education: Research results

Another topic addressed in the study was outdoor education. The aim was to explore participants’ understanding of the concept and the practical possibilities for implementing its principles. The graphic below (Fig. 2) presents the associations with outdoor education provided by teachers from four countries. The most frequently mentioned associations included *nature, observation, experiments, joy, health, garden, and experience*, among others.

Research findings published by Martyna Szczotka and Katarzyna Szewczuk (2023) offer more detailed insight into how the surveyed teachers conceptualise outdoor education. The study involved 18 participants (divided into three focus groups), aged between 21 and 51. Half of the teachers worked in public kindergartens (9) and the other half in non-public institutions (9).

The researchers recorded 72 associations with outdoor education, which they categorised into six groups: (1) Development of children’s knowledge and skills—28%; (2) Teaching method—19%; (3) Physical activity and engaging forms of working with

uses the natural environment” (Leśny, 2024, p. 4). By this definition, a walk or free play in the preschool garden does not necessarily qualify as outdoor education. Nevertheless, it is important to note that the surveyed teachers are aware of its significance for children’s development. The key question is: how is this awareness reflected in practice?

Integrating Outdoor Education into Teaching Practice

According to the teachers surveyed, incorporating outdoor education into daily practice is an excellent way of supporting children’s cognitive, emotional, social, and motor development. Based on examples from Spain, Poland, Italy, and Ireland, a proposal emerged for a comprehensive approach that combines various activities with clear educational goals.

A fundamental element of this approach is education through direct experiences in nature. In preschool settings, this can include planting and caring for plants, observing animals, and conducting experiments involving plants or weather phenomena. Such activities teach children about plant life cycles, instil respect for nature, cultivate responsibility and patience, and teach them about animal species and behaviours. Outdoor experiments can also introduce concepts such as photosynthesis, as well as the properties of water, soil, rocks, and minerals.

The Polish group of teachers most frequently use the preschool garden for themed activities; for example, learning about dinosaurs through archaeological play in the sandbox, studying the Solar System, or discovering plants through sowing and planting. These activities are often combined with outdoor games, observations, experiments, and hands-on experiences such as “mud kitchens”. Activities beyond the preschool grounds take the form of field trips to parks, sites of interest, or centres that offer engaging workshops (Szczotka & Szewczuk, 2023).

Another key topic was integrating outdoor education into the curriculum, particularly within the STEAM framework. The participants proposed specific methods and activity ideas connected to different scientific areas:

- Science: observing nature, conducting experiments with water, light, and soil.

- Technology and Engineering: building simple structures from sticks, creating basic irrigation systems.
- Art: drawing outdoors, creating artworks with leaves, mud, sand, and natural dyes.
- Mathematics: counting stones, measuring tree trunks, comparing shapes and sizes and logical and causal thinking: solving problems during play and hands-on experiments.

The participants also identified challenges and barriers to implementing preschool education content through outdoor learning.

The first challenge involves parents, who may worry about their children's health (exposure to cold, rain, or dirt) and often do not fully understand the value of learning outside the classroom. Teachers, in turn, frequently raise concerns about safety (e.g., children putting stones in their mouths) and report a lack of experience or training in outdoor education. A further challenge relates to spatial and infrastructural constraints, such as limited greenery around facilities, small cloakrooms, and no facilities for drying wet clothing. In addition, some teachers cite a lack of financial resources to purchase protective clothing, tools, or materials as a significant barrier.

Despite these obstacles, the surveyed teachers acknowledged the importance of children spending as much time outdoors as possible. They also strive to design and carry out activities outside the preschool building, although such opportunities are not very frequent. Focus group research with the Polish cohort partly confirms findings from previous studies (Michalak & Parczewska, 2019), which point to the complete absence or marginal presence of outdoor activities in primary schools (Szczołka & Szewczuk, 2024). However, it seems that implementing the principles of outdoor education is generally easier in preschools—a recommendation also emphasised in our project.

Conclusions and recommendations from the pilot study

Differences in how ESD is understood have a direct impact on teaching practice. For this reason, materials designed for teachers should include clear explanations of theoretical assumptions, tailored to cultural and geographical contexts. It is important to raise awareness among both

parents and teachers that outdoor education supports not only learning but also emotional, social, and physical development. Workshops and practical recommendations could be an effective way to promote this understanding.

The principles of ESD can be successfully combined with both the STEAM approach and outdoor education, and this integration should be reflected in curricula and lesson plans.

Collaboration with parents and the local community is essential and should be supported in teachers' work. Teachers need access to practical training, inspiring teaching resources, and professional support networks. To meet this need, a syllabus for an academic course and an online course should be developed for educators interested in these topics. Even in less favourable conditions, elements of nature-based education can be implemented. Creativity and flexibility should be encouraged, and methodological materials should offer teachers practical, adaptable solutions.

A common theme in all approaches to ESD is the recognition of the teacher's role as a model for shaping children's attitudes. All teachers acknowledged the value of experiential learning, both indoors and outdoors (e.g., in parks and gardens). ESD should not be treated as a separate subject, but as one that permeates all aspects of preschool education, from social relationships to daily routines and food choices.

2.2. Learning Activities: Presentation of the project results

Based on the needs identified by the surveyed teachers—stemming from varying interpretations of sustainable development and difficulties in implementing all three pillars of sustainability into educational practice—the project team established priorities for selecting topics and structuring lesson plans. The methodological requirements of the partner countries were also taken into account.

In order to offer teachers practical solutions, the project team reviewed available resources and examples of good practice, adhering to

the theoretical principles of sustainable development, outdoor education, and STEAM. From these, the team selected lesson plans that met the criteria in at least one of the above areas and could be adapted as needed. Each partner was tasked with developing 25 lesson plans, which were then published on the project website and organised by season and Earth sphere (atmosphere, biosphere, geosphere, and hydrosphere). This classification makes it easier for teachers to search for and select activities that meet their specific needs.

The *Kids Lab 4 Sustainability* project website also features a lesson plan search engine with five filters: language, STEAM field, season, Earth sphere, and lesson duration (short, medium, long, or more than one day). Lesson plans are available in English, Spanish, Catalan, Polish, and Italian. Each lesson plan follows a structured format, including: lesson topic, general objectives, vocabulary-key words, sustainable development competencies, pillars of sustainable development, STEAM fields, teaching methodology/activity sequence, expected learning outcomes, evaluation methods, teaching materials and equipment (tools, ingredients, etc.), learning environment, literature/sources, authors.

This section on Learning Activities contains lesson plans developed by both the project team and members of the Learning Community. The lesson plans underwent a multi-stage evaluation process. Users can also rate and comment on them directly on the project website.

Sample lesson topics by season include:

- **Spring:** "What do slugs do in the garden?" "Seed bombs for babies", "Mud kitchen for babies".
- **Summer:** "We reuse: Construction of musical instruments with recycled material", "We reduce: We wake up", "Plants phototropism—Developing STEAM skills observing the phototropism".
- **Autumn:** "The colour of the sky", "Sculpture with pieces of nature", "Plastic ocean".
- **Winter:** "Research games with ice cubes—using ice for artistic activity", "Glacier melt", "How to take advantage of frost?—winter research games".

Below are three selected lesson plans that have been evaluated by teachers as good practices.

First proposal for children's activities

Lesson topic:

- Seed bombs for babies

Overall objectives:

- To support babies and toddlers in exploring soil through sensory play.
- To introduce the concept of planting seeds.

Vocabulary–Keywords:

- soil
- seeds
- water
- grow

Sustainability skills developed:

- self-awareness

Pillars of sustainability included:

- **E c o l o g i c a l:** Supporting very young children in developing a connection with the natural world.
- **S o c i a l:** Understanding how human actions affect the planet's sustainability.
- **E c o n o m i c:** Caring for and teaching very young children using as few materials as possible.

STEAM domains:

- Science (S)
- Mathematics (M)

Teaching methods/activity outline:

- The teacher places soil, water, and wildflower seeds (safe if ingested) into a large container and begins to play with the mixture. When the babies and toddlers join in, the teacher demonstrates how to shape the mixture into balls. Once the children lose interest in the container, the teacher invites them to throw the seed balls around the garden.

Expected learning outcomes:

By the end of the activity, the child will be able to:

- Contribute to biodiversity by planting seeds.
- Engage in a projection activity using the seed balls.

Assessment:

- The teacher evaluates learning through attuned, responsive interactions.

Equipment and materials:

- soil
- water
- container
- seeds safe for ingestion

Setting

- classroom
- kitchen
- or outdoor garden

References–sources:

- <https://runwildmychild.com/wildflower-seed-bombs/>

Authors:

- Garret Scally, Trish McLaughlin, Orlene O'Brien, Paula Kelly, Aoife O'Dowd, Sinead McCaffery, Eimear Scanlon, Ava Callaghan, DCU Ireland

Second proposal for children's activities

Lesson topic:

- How many plants grow in a flower meadow? (biodiversity features).

Overall objectives:

- to experience the concept of biodiversity;
- to understand the differences between a flower meadow and a lawn;
- to develop counting and conversion skills;

- to identify wildflowers;
- to raise awareness of the importance of biodiversity and evaluate human activities that affect it.

Vocabulary—keywords:

- biodiversity
- flower meadow
- lawn

Sustainability skills developed:

- systems thinking
- anticipatory competence
- strategic competence
- teamwork and cooperation

Pillars of sustainability included:

- socio-cultural
- economic
- ecological

STEAM domains:

- Science (S)
- Mathematics (M)
- Art (A)
- Technology (T)

Teaching methods/activity outline:

Introduction

Begin with a discussion:

- What do you think is the difference between a lawn and a flower meadow?
- How many different plants grow on a lawn, and how many in a meadow?
- The teacher records the children's answers.

Main activity

Working in groups, children examine a section of lawn (and later, a section of meadow) marked off with string.

They observe, count, and name the plants they recognise. If they do not know a plant, they can ask the teacher or use a plant identification app.

The teacher records the observations together with the children.

The results are compared between the lawn and the meadow.

Discussion:

- Where did we find a greater variety of plants? Where were there more insects? Which was more colourful?
- Which place is friendlier to insects, animals, and people? Why?

Summary

- Activity—"Detective game."

Children look for something in the meadow of a specific colour (yellow, orange, blue, purple, brown, pink, white, etc.).

Each child receives a piece of coloured paper and must find one item in the meadow matching that colour.

The found item is attached to the paper with a clip.

Children share their findings, and together they create a poster of the different plants that they discovered.

Conclude by explaining: *There are more different plants and insects in a meadow—this is called biodiversity.*

Expected learning outcomes:

The child will be able to:

- Explain what biodiversity is.
- Count and compare the number of plants found in the meadow and on the lawn.
- Name selected plants, flowers, and insects.
- Identify plants of different colours.

Assessment

Discussion prompts:

- Biodiversity is...
- A flower meadow is more insect-friendly because...

Equipment and materials (tools, ingredients etc.)

- string (e.g., one metre per section; number of sections depends on the number of groups)
- coloured cards and clips
- magnifying glasses

Learning Environment

- meadow and lawn near the kindergarten

References—sources:

- <https://wklasie.uniwersytetdzieci.pl/scenariusz/jak-zmierzyc-bioroznorodnosc>
- <https://tuptuptup.org.pl/bioroznorodnosc/>

Author:

- Barbara Surma, UIK Poland

Third proposal for children's activities

Lesson topic:

- Water as a source of energy—Constructing a water turbine

Overall objectives:

- to introduce the concept of water energy and allow children to observe how a water turbine works;
- to develop the ability to listen to and follow instructions;
- to strengthen observation skills;
- to build teamwork skills;
- to expand children's knowledge of hydropower and other renewable sources of energy.

Vocabulary—keywords:

- water turbine
- water energy
- hydropower
- renewable sources of energy

Sustainable skills developed:

- systems thinking,
- collaboration,
- integrated problem-solving

Pillars of sustainability included:

- economic
- ecological

STEAM domains:

- Science (S),
- Technology (T),
- Engineering (E),
- Mathematics (M)

Teaching methods/activity outline:

Introduction

Start with a discussion about the different ways people use water:

- What do we use water for?
- When and where can we use it?
- How do we use water in our everyday lives?
- Show the educational video: "From mill wheels to hydropower plants": <https://www.youtube.com/watch?v=avyh-MMXBjo>

Main activity

Construction of a water turbine. The children are divided into groups.

Before class, the teacher prepares the materials:

- They cut off the top of a plastic bottle and make two opposite cuts, each about 2 cm deep and 3 mm wide.
- They cut a piece of plastic card into four equal parts.
- They cut four notches into the bottle cap or cork to fit each of the four card pieces.

Children construct a turbine by combining the elements. They insert the card pieces into the notches on the cap or cork, creating the turbine wheel.

Then, they insert toothpicks or cut skewers into each side of the cork.

Finally, the teacher asks the children to direct a stream of water from the bottle onto turbine blades.

Children observe the movement of the turbine and discuss how hydropower is generated.

Expected learning outcomes:

The child will be able to:

- Follow step-by-step instructions for building a water turbine.
- Explain the role of water in generating renewable energy.
- Make careful observations. Collaborate in small groups.

Assessment

- Observing the process of learning, assessing the ability to explain the concepts with own words Observation of participation and engagement during the activity.
- Evaluation of the child's ability to explain the concepts in their own words.

Equipment and materials (tools, ingredients, etc.):

materials per group (prepared in advance by the teacher):

- 1 plastic bottle
- 1 piece of plastic card (repurposed)
- 1 cap or cork
- scissors, knife (for teacher use)
- two toothpicks or skewers
- bottles filled with water

Setting:

- classroom or preschool garden

References—sources:

- <https://www.youtube.com/watch?v=avyh-MMXBjo>
- <https://tuptuptup.org.pl/projekt-inzynieryjny-energia-wodna/>

Authors:

- Gabriela Madej, Natalia Rapacz, Teresa Stanek, Sylwia Szewczyk (mentor: Barbara Surma), UIK, Poland

2.3. Learning Pathways: Presentation of the project results

The next step was to evaluate the proposed activities in practice and develop the so-called *learning pathways*, in line with the methodologies used in participating institutions. Since kindergartens operate on a weekly timetable, our goal was to combine individual lesson scenarios into thematic blocks and create methodological guidelines for their implementation.

Following an analysis of the objectives and content of the scenarios, we developed 16 learning pathways designed to inspire the Learning Community and teachers in search of effective practices. After the completion of this stage of the project, an additional 14 learning pathways—developed during training sessions with the Learning Community in the partner countries—were published on the project website.

The topics of the developed learning pathways included:

- Flower meadow—habitat for various tenants.
- The Colours of Spring.
- A thousand facets of autumn.
- Building Sustainable Relationships.
- Circular Economy.
- Fire!
- Water!
- Let's take care of the oceans!
- The Force of the Earth.
- Earth—Amazing planet.
- Rocks and minerals—under the magnifying glass of a geologist.
- The soil—plants' natural habitat.
- Earthworm—gardener's little helper.
- Wind—an ally or enemy?

- The Child in the Air–Discovering Air.
- Ice—not such a terrible hero of the frosty lands.

Each methodological description of a learning pathway includes selected general objectives set out in the scenarios, expected learning outcomes for the entire block of lessons, evaluation criteria, and a three-stage structure of proposed activities. The pathway incorporates all three pillars of sustainable development. Teachers may also select alternative activities and adapt them to the children’s age, available time, and location.

An example of one such pathway can be found on the project website: <https://kidslab4sustainability.eu/earthworm-gardeners-little-helper-2/>

Learning pathway title: Earthworm—Gardener’s Little Helper

Overall objectives:

- to develop an understanding of the role of earthworms in loosening and aerating soil;
- to introduce the concepts of “compost”, “composter”, and “fertilizer—natural versus chemical”;
- to build skills in identifying biodegradable waste suitable for composting;
- to strengthen understanding of the ecological and economic benefits of composting and earthworm farming;
- to instil a sense of responsibility for the natural environment of the garden;
- to raise awareness of cultural and linguistic diversity.

Expected learning outcomes:

The child will be able to:

- distinguish earthworms from other similar creatures;
- explain the role of earthworms in loosening soil and define the concepts of bio-waste, compost, and composter;
- take consistent action to reduce bio-waste in landfills by responsibly selecting bio-waste for the preschool composter;

- understand and value the relationship between the natural world and human activities;
- recognise the word “earthworm” in several selected languages.

Evaluation:

Initial –discussion:

- “What do we know about earthworms?” Identifying different species of earthworms using illustrations from nature books. Attempting to answer the question: How are earthworms different from other creatures?

Ongoing –As described in each activity resource.

Final –Designing a poster to promote “Earthworm farming/breeding culture”.

Pathway structure

Stage I: Ecological pillar

- Learning about the structure and habitat of earthworms, establishing an earthworm breeding setup in the kindergarten classroom, and observing their role in loosening the soil. *Are earthworms useful? –Growing earthworms in a jar* <https://kidslab4sustainability.eu/are-earthworms-useful-growing-earthworms-in-a-jar/>

Stage II: Ecological and economical pillars

- Understanding the relationship between human activity and the work of earthworms (linking ecology and economy) by setting up a composter in the kindergarten garden. Developing the ability to consistently select bio-waste suitable for compost production. Shaping ecological awareness, understanding the role of natural fertilizers in the garden, and recognising the economic benefits of using them. Building a composter in the preschool garden, exploring the concept of bio-waste, and learning to distinguish bio-waste generated at home from that generated in the garden.
- Composter and useful earthworms <https://kidslab4sustainability.eu/composter-and-useful-earthworms/>

Stage III: Socio-cultural pillar

Raising awareness of cultural and linguistic diversity through narrative and play activities that use the earthworm theme, supported by modern technologies.

Earthworm journeys: Using knowledge about earthworms for a coding activity <https://kidslab4sustainability.eu/earthworm-journeys/>

Assessment of learning activities and learning pathways—results of ongoing evaluation

Taking into account the difficulties and concerns previously reported by the surveyed teachers—often stemming from their own experiences of learning mathematics and other science subjects—our goal was to strengthen their sense of effectiveness and self-confidence. The scenarios developed for children, along with other materials, were made openly accessible and presented during workshops for teachers, preschool education students, and academic staff.

Each partner in the Learning Community conducted a series of training sessions aimed at introducing the concepts and goals of sustainable development in early childhood education, as well as the key competencies required for sustainability. These sessions involved testing selected resources in practice, evaluating them, and subsequently collaborating to develop new scenarios and educational pathways.

The Learning Community in each country consisted of at least nine members, including invited preschool teachers, academic staff, and students in teacher training programs. The training was delivered by partners from four universities: LUMSA, UIC, DCU, and UIK. Participants had the opportunity to study examples of good practice and to test and evaluate selected scenarios from the Kids Lab for Sustainability project repository.

In order to ensure a cross-cultural evaluation process, the partners agreed that each Learning Community would test lesson plans developed by a team from another country. The Polish community tested and evaluated resources developed by DCU; the Irish community tested materials from LUMSA; the Italian community reviewed resources from UIC; and the Spanish community tested materials prepared by UIK.

As part of the Learning Community in Poland, the staff of the Ignatian University in Cracow engaged a relatively large group of participants in the training. According to Katarzyna Szewczuk, this group comprised preschool teachers (3), teacher training students (81), and academic staff (3), who were tasked with evaluating the scenarios and methodological guidelines for teachers (Focus on, 2024, p. 61). After completing the entire workshop cycle, participants provided evaluations of our proposed activities for children as part of the ongoing assessment process.

Everyone appreciated the opportunity to apply theory in practice. After testing the lesson plan *Are earthworms useful?*, they concluded:

Setting up an earthworm farm is great fun. Conducting classes in this way makes it easier to remember and understand the role of earthworms in the soil. We were active the whole time, working with different materials (Szewczuk, 2024, p. 63).

During one of the workshops, participants also had the chance to experience STEAM education firsthand. In particular, they discovered that it is a holistic approach, in which it is important to combine multiple disciplines—in this case, science and art. For example, while learning about the properties of soil, it can also be used for artistic expression (see Figs. 1 and 2).

Fig. 1 Painting with Soil



Fig. 2 Painting with Soil



Another outcome of participating in the Learning Community, according to respondents, was the development of new teaching skills in areas such as collaboration on educational pathway design, sustainable development, STEAM education, and outdoor education:

Interesting exercises that kept us engaged. I was eager to test the lesson plans because they were different from what I had seen before. At the same time, creating my own lesson plans gave me the chance to express my creativity. (Szewczuk, 2024, p. 64).

Similar feedback about the workshops and programme proposals was expressed by participants from other Learning Communities in Italy, Ireland, and Spain.

The main outcome of this stage of the project was the expansion of the “Repository” with new learning activities and learning pathways (<https://kidslab4sustainability.eu/learning-pathways/#new-learning-pathways-1>) and the enhancement of participants’ teaching skills.

The Learning Community’s evaluation of the workshops also helped improve the quality of the website. Based on their suggestions, direct access to the repository was added, and the project dictionary was expanded with new terms (e.g., *climate anxiety*). It is worth noting that the content published on the project website received very high ratings. Participants found it useful, comprehensive, and full of fresh ideas for implementing sustainable development activities with preschool children. At the same time, evaluations of the repository resources ranged from 3 to 5, with none of the scenarios rated as poor or low quality.

Chapter 3

Preschool Curriculum “Outdoor STEAM for sustainability” results and research findings

The next stage of our project was to design a preschool curriculum aimed at improving the quality of education at the ECEC level. In addition to the teaching materials available in the Repository, the curriculum included the creation of a teacher’s handbook consisting of two parts: theoretical principles and methodological guidelines. The University of Inclusive Childhood (UIC) coordinated the development of the first part of the handbook, *Theoretical Assumptions of the Preschool Curriculum*. In collaboration with partners from DCU, LUMSA, and IF, the team agreed on its structure and content, focusing on three main educational components: (1) teaching content related to sustainable development, (2) teaching and learning methodology through the STEAM approach, and (3) the educational environment—outdoor learning.

The Ignatianum Foundation was responsible for the second part of the handbook. The team developed practical guidelines for teachers, which were translated into the national languages of the partner countries. FPM published all materials prepared by the partners on the KidsLab4Sustainability project website, which make up the preschool curriculum *Outdoor STEAM* activities for sustainable development. These resources are available at: <https://kidslab4sustainability.eu/preschool-curriculum/#PreschoolCurriculum>. Work on the teacher’s handbook took place between May 2022 and February 2023. During this time, training sessions and pilot studies were also conducted to implement and evaluate the programme in preschools.

This chapter presents the theoretical framework of the preschool curriculum and the methodological guidelines for teachers, explaining

how to use and further develop the materials in the Repository. The final subsection describes the results of the ongoing evaluation carried out by preschool teachers, children and their parents.

3.1. Theoretical framework for the preschool curriculum

The first part of the teacher’s handbook introduces the concepts of education for sustainable development, the STEAM approach, and outdoor education. In each of these three areas, we pose and answer key questions relating to the definition of terms, identification of objectives, historical background, significance for child development, and the challenges involved.

1. EDUCATION FOR SUSTAINABILITY

What is Education for Sustainability?

If sustainability is defined as meeting present human needs without compromising the ability of future generations to meet their own, then education for sustainable development is the approach that seeks to achieve that goal. Education for sustainability involves equipping learners of all ages with the relevant knowledge, skills, and values that motivate them to become *informed, active citizens* who take action for a more sustainable future (Department of Education and Skills, 2014, p. 7).

Why Education for Sustainability?

Humanity and the planet face unprecedented environmental challenges. In 2015, in response to these growing threats, the United Nations General Assembly adopted the *2030 Agenda for Sustainable Development*—a global plan of action for people, planet, prosperity, and peace (UN, 2015). The agenda sets out 17 integrated and indivisible goals that encompass the three pillars of sustainability: ecological, social, and economic.

Countries that endorsed the agenda committed to working together to eradicate poverty, promoting sustainable consumption and production, taking urgent action against climate change, and building equitable, inclusive, and peaceful communities by 2030. Although arguably ambitious and optimistic, this action plan calls on signatory nations to embed its goals into existing institutions, particularly education systems, so they can be realised across generations.

Sustainability Competences

A defining feature of education for sustainability is its intentional design to support UNESCO's sustainability competencies (UNESCO, 2017), which include:

- **Systems thinking:** The ability to recognise and understand relationships; analyse complex systems; consider how systems operate within different domains and scales; and to deal with uncertainty.
- **Anticipatory competency:** The ability to understand and evaluate multiple futures—possible, probable, and desirable; to create personal visions for the future; apply the precautionary principle; assess the consequences of actions; and manage risks and change.
- **Normative competency:** The ability to understand and reflect on the norms and values underlying one's actions, and to negotiate sustainability values, principles, goals, and targets in contexts of conflicting interests, uncertain knowledge, and contradictions.
- **Strategic competency:** The ability to work collectively to design and implement innovative actions that advance sustainability both locally and more broadly.
- **Collaboration:** The ability to learn from others; understand and respect the needs, perspectives, and actions of others (empathy); relate to and be sensitive to others, demonstrate empathetic leadership; manage group conflicts; and facilitate collaborative, participatory problem-solving.
- **Critical thinking:** The ability to question norms, practices, and opinions; reflect on one's own values, perceptions, and actions; and take an informed position in sustainability discourse.

- **Self-awareness:** The ability to reflect on one’s role in the local community and (global) society; continually evaluate and strengthen one’s motivation for action; and manage personal feelings and aspirations.
- **Integrated problem-solving:** The overarching ability to apply diverse problem-solving approaches to complex sustainability problems and develop viable, inclusive, and equitable solutions that promote sustainable development while integrating the other competencies.

Education for sustainability in early childhood: Then and now

Education for sustainability is not a new concept, quite the opposite, particularly in early childhood education (Early Childhood Education and Care, ECEC), where it has long-standing roots. In 1924, Rudolf Steiner observed that “for children, everything is one, and they are also one with their surroundings”, suggesting through his teaching and research that normative, interpersonal, and intrapersonal skills naturally emerge in young children (Steiner, 1924).

Around the same period, Maria Montessori argued that “humanity must acquire a new consciousness” and that, through the education of young children, we must “radically transform society through education” (cited in Boyd, 2018, p. 230). This perspective underscores the importance—and early recognition—of what are now considered contemporary social, economic, and ecological sustainability competencies. Today’s ECE frameworks lay the foundations for children’s intellectual, psychological, emotional, and social development, offering “enormous potential in fostering values, attitudes, skills, and behaviours that support sustainable development” (Samuelson & Kaga, 2008). Moreover, the widespread integration of nature and ecological themes into teaching practices further enhances children’s ability to develop and refine sustainability competencies (Ernst & Burcak, 2019).

The challenges in early childhood

Incorporating comprehensive early childhood frameworks that advocate for nature and ecological education plays a crucial role in fostering sustainability skills. However, Sue Elliot (2016, p. 5) acknowledges

that such frameworks alone are insufficient to address the breadth and complexity of sustainability. She observes that educators often mistakenly assume that children will naturally adopt a sustainable worldview, embrace ethical principles, and become proactive sustainability advocates simply by engaging with nature and ecological practices. Elliot encourages educators to move beyond familiar pedagogical methods, such as demonstrating care for the natural world, toward more demanding approaches that engage children in exploring worldviews, ethics, and values.

While today's children stand to benefit most from an immediate and significant shift in human behaviour toward sustainability, David Elliot's call for very young children to contribute to the increasingly urgent global dialogue on sustainability demands both sensitivity and reflection. As Sobel cautions, "If we want children to flourish, to become truly empowered, then let us allow them to love the earth before we ask them to save it" (1996, p. 121).

This section outlines the concept of sustainability and its role in early childhood education. It defines sustainability and examines the goals and competencies outlined in UNESCO's sustainability action plan, positioning this plan as part of the rationale for integrating sustainability discourse into early childhood classrooms. Finally, it argues that while instilling a love for nature and compassion for others is not, in itself, enough to turn young children into informed citizens who can take a stand on sustainability, nurturing these values is a reasonable and necessary starting point.

2. STEAM EDUCATION

What is STEAM Education?

STEAM education is a modern, highly effective approach to teaching and learning that combines the sciences and the humanities, both of which are crucial for economic growth and the development of a healthy, safe society. STEAM is an acronym for five pillars of modern education: Science, Technology, Engineering, Arts, and Mathematics. It is more than

a simple combination of school subjects—it is an integrated, holistic approach to teaching that takes into account its multi- and interdisciplinary nature.

The aim of STEAM education is to build knowledge as a whole (Morrison, 2006), emerging from the interplay of all these disciplines, which not only coexist but also overlap and interact in daily life. Children naturally construct knowledge holistically: when acting, creating, solving scientific problems, and recognising that what they learn has practical applications. As Rodger Bybee (2010) notes, STEAM education enables learners to solve real problems in the real world.

The educational process

When a child is empowered to discover the connections between Science, Technology, Engineering, Arts, and Mathematics, their knowledge becomes more holistic and in-depth. Discovering that this knowledge has real-world applications can motivate them to learn and may inspire them to pursue a STEAM-related profession in the future.

In this approach, children learn not only how to acquire knowledge but also how to apply it in practice. The educational process incorporates three types of knowledge:

1. Knowledge of states and their relationships
2. Knowledge of methods of mental and observable activity
3. Meta-knowledge resulting from reflection on both the previous types of knowledge and on oneself (Surma, 2021).

Thus, STEAM education draws on both declarative and procedural knowledge. Declarative knowledge refers to a system of semantic knowledge about facts, which can be easily verbalised and conveyed to others. Procedural knowledge, by contrast, relates to the ability to perform activities. It is acquired through internalised procedures, as well as heuristic and algorithmic rules, that guide the performance of physical and mental tasks. This form of knowledge is most often automated and applied indirectly by using the appropriate procedure in a specific context. Procedural knowledge is gained through action, and in some cases, can be converted into declarative knowledge (Surma, 2021).

Natural Knowledge versus Scholastic Knowledge

In STEAM education, the focus is on natural rather than scholastic knowledge, and on the conditions under which learners acquire it. Scholastic knowledge results from verbal transmission without active engagement or direct personal contact with the subject matter. It is characterised by reproducibility and rote memorisation of information delivered solely through words.

Natural knowledge, on the other hand, develops organically in the course of the learner's activities and its practical application of in various contexts. While information gained through verbal instruction alone can be repeated, it often remains superficial unless reinforced by experiential learning. Therefore, in planning STEAM based activities for children, it is vital to create opportunities for experiential learning by integrating sensory, real-world experiences with procedural knowledge developed through action.

Equally important is designing learning experiences that promote independent exploration, discovery, research, and problem-solving, all appropriate to the child's developmental stage and to cultural context. STEAM education is valuable for supporting independent inquiry through experimentation and the cultivation of scientific thinking (Zdybel et al., 2020).

STEAM and Inquiry-Based Science Education (IBSE)

Shaping 21st-century competencies—developing concepts in a functional way and building on children's prior knowledge and experiences—requires cognitive engagement, which should be preceded by emotional engagement and intrinsic motivation. Research has shown that using reasoning and inquiry-based methods to spark children's interest in STEAM, even at the preschool stage, is both desirable and achievable.

STEAM education is a strategy partly based on scientific inquiry (IBSE and IBL) and project-based learning. Its main advantage lies in awakening children's curiosity, true love and passion for learning, enjoyment of collaboration, joy in being around others, and a sense of self-discovery and understanding of the world. Inquiry-Based Science Education (IBSE) and Inquiry-Based Learning (IBL) are part of the family of problem-based

methods that are used both in STEAM education (Szewczuk, 2021) and in education for sustainable development.

When applying the IBSE method, educators often use the 5E Model (Engage, Explore, Explain, Elaborate, Evaluate) (Università Kore di Enna, 2021). In the Engage phase, children are introduced to a phenomenon or topic, such as air pollution, climate change, technology, or water as a source of life. Topics can cover scientific concepts (*What is carbon dioxide?*) as well as ideas from education for sustainable development (*What is justice? What rights do children have? What are ecosystems and why do they matter for people and the planet? How is a sewage treatment plant built?*). At this stage, children organise their knowledge by freely sharing their opinions and observations. They answer the question: *What do we already know?* The goal is to capture their attention, spark curiosity, awaken the desire to learn, and build intrinsic motivation.

In the Explore phase, children formulate research questions and hypotheses, plan activities and methods for testing their hypotheses, carry out experiments, collect data, and begin analysing the results. They consider: *What do we want to know, and how will we find out?* The teacher encourages and supports children's initiatives while allowing them to take the lead in conducting experiments and other activities. In the Explain phase, children discuss the results of their investigations. They connect their findings to theoretical concepts that help place their discoveries in a wider context. The Elaborate phase involves extending and applying newly acquired knowledge. Children identify new research questions inspired by their findings, conclusions and doubts. In the Evaluate phase, assessment focuses on both feedback from the activity itself and self-assessment.

This learning process develops four key 21st-century competencies: Creativity, Collaboration, Critical thinking and Communication. Most importantly, it nurtures a lasting passion for learning. Young children are naturally curious and eager to explore; STEAM education channels this curiosity into discovery and strengthens a sense of dignity and confidence in their own abilities.

3. OUTDOOR EDUCATION

Introducing outdoor education

Outdoor education refers to a wide range of educational practices that share one common denominator: the use of diverse outdoor settings as a learning environment. Thus, the physical setting is the key distinguishing element: natural environments become the primary location for learning (Farné & Agostini, 2014).

The pedagogical approach behind outdoor education does not prescribe specific activities, learning pathways, or fixed goals. Instead, objectives and methods are determined by the particular educational context (e.g., school-based programs or extracurricular settings) and the choices of educators. However, research shows that outdoor settings increase learning opportunities, as they encourage children to use and develop certain skills—such as fine motor skills—more frequently and with greater intensity than in indoor settings (Brymer & Renshaw, 2010).

In short, outdoor education is not a new or entirely separate form of education. Rather, it represents a pedagogical recognition of the many benefits that environmental settings can bring to the learning process. It offers a different way of teaching, synchronising the pace of learning with experiential activities, and treating the “external” environment as a natural and integral counterpart to the “internal” classroom environment (Gilbertson et al., 2022).

The main characteristics and benefits of outdoor education

According to Phyllis Ford (1986), the philosophy of outdoor education comes down to four main principles:

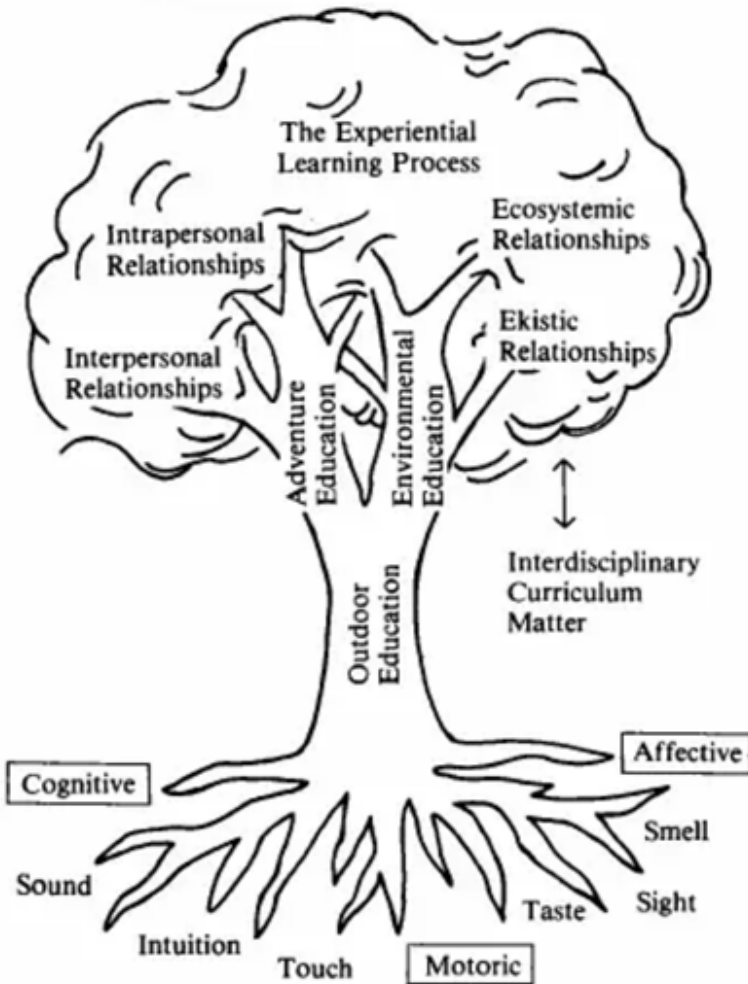
1. A human commitment and responsibility to care for the land
2. Belief in the interconnectedness of all elements of the ecosystem
3. Understanding the natural environment as a setting for leisure
4. Recognition that outdoor education is an ongoing educational experience.

One of the best-known definitions comes from Simon Priest (1986), who described outdoor education as an “umbrella term” (Figure 1) that includes all forms of education about the outdoors, e.g., adventure education.

He identified six key characteristics of outdoor education:

1. It is a method of learning;
2. It is experiential;
3. It takes place primarily outdoors;
4. It engages the senses;
5. It is concerned with the relationship between people and the natural environment and its resources;
6. It is holistic: the self, others, and nature are interconnected.

Figure 1. Priest's (1986) model of outdoor education.



More recent research shows that outdoor education can reduce anxiety, encourage prosocial behaviour (Campos et al., 2004; Sameroff & Fiese, 2000), and enhance communication and collaboration skills (Fiskum & Jacobsen, 2012). In addition, children who have access to outdoor education tend to have better physical health, higher self-efficacy, and greater resilience (Ewert & Sibthorp, 2014).

A brief overview of the history of outdoor education

Several educators have demonstrated the importance of the natural environment in learning, beginning with the Romantic era, when the rise of urban society weakened the connection between human life and nature. Jean-Jacques Rousseau argued that the outdoors is the most suitable environment for children's development because it encourages greater freedom and responsibility, allows the acquisition of cognitive skills through direct experience, and stimulates all the senses (Cambi, 2011).

Rousseau's ideas inspired the pedagogical model of Friedrich Fröbel (1782–1852), who developed the concept of Kindergarten, meaning "children's garden", a place where children cared for gardens and plants, learning responsibility while playing in close contact with nature (Kustosz, 2020). In his educational philosophy, Fröbel envisioned three types of activities:

1. Playing with inanimate objects.
2. Playing with other children.
3. Gardening and caring for animals to teach empathy for living things.

After Fröbel's death, his outdoor school model was adopted in schools across Northern Europe, the United States, and Japan, paving the way for what would become modern outdoor education.

Outdoor education in practice: The example of kindergarten in the forest

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The educational design of a Kindergarten in the Forest is rooted in five fundamental principles:

- Emphasising outdoor space as a primary educational setting.
- Prioritising the educator–child relationship.
- Valuing direct experience as the cornerstone of instruction.
- Recognising the significance of emotions.
- Using play as the preferred teaching method and a primary means of communication.

This approach offers multiple benefits. It allows children, and educators, to gain knowledge through hands-on observation and direct experience in real-life situations (Crudelli et al., 2012).

Kindergartens in the forest are a great example of how immersing children in nature—and giving them child-friendly space and unhurried time—can enrich their learning and development. Learning in and through nature fosters sustainable rather than exploitative attitudes and behaviours (Belvedere, 2013). In essence, this model is an educational strategy that is oriented toward high-quality experiences in direct contact with the environment and its real phenomena, and that stimulates cognitive development through sensory–motor activity. Equal importance is given to “the connection between outdoor education and the need of new generations to reclaim the centrality of their bodies, the

need for movement, spontaneous play, and psychophysical well-being” (Ceciliani, 2014).

Outdoor education and the STEAM approach

In today’s world, there is a growing emphasis on developing abilities in STEAM fields: Science, Technology, Engineering, Arts, and Mathematics. For this reason, it is crucial for educational institutions, beginning in the earliest stages of schooling, to incorporate activities based on real-world scenarios. Such activities strengthen students’ skills and enable them to better understand and actively engage with their surroundings.

In this context, there is a strong link between outdoor education and the STEAM approach. According to Sally Kendall et al. (2006), thoughtfully designed outdoor educational activities can be considered part of a STEAM learning strategy. These activities provide direct, real-world experiences and create strong connections between children and their environment, often challenging them to find solutions to authentic problems (Haas et al., 2021).

Outdoor settings offer numerous natural elements that can be used as “tools” for improving STEAM skills. For example, time spent in nature allows children to interact with sunlight, air, water, and habitats; reimagine playground spaces; make empirical observations; generate and test hypotheses; and more. In this way, children can build their STEAM competencies within a framework of sustainable development (Keane & Keane, 2016).

3.2. Guidelines for teachers

The second part of the handbook lays out a teaching strategy based on the STEAM approach. To apply it successfully, it is important to understand its principles in the context of sustainable development and outdoor education, as well as the methods for its practical application. As in the first part, we answer key questions that can guide the implementation of our preschool curriculum. We also review the provided

teaching materials (including lesson scenarios and learning paths), explain how to use them, and encourage you to create your own.

The project website also offers step-by-step instructions for designing a custom learning path, along with useful links: <https://kidslab4sustainability.eu/wskazowki-dla-nauczycieli/#p1>

What is STEAM?

STEAM is a holistic, inquiry-based learning strategy that supports children in solving complex, interdisciplinary, and practical problems within contexts closely related to their everyday lives. At the early education level, this approach strengthens children's self-confidence, fosters a sense of efficacy, and nurtures a positive self-image as learners.

STEAM also shifts the perspective of educators—from focusing on measuring achievements in reading and writing to emphasizing the development of intellectual abilities such as critical and creative thinking, observation, prediction, comparison, drawing conclusions, and reflection. Skills like reading, writing, and counting become tools for thinking and building a culture of collaborative learning.

Research shows that early STEAM education not only cultivates children's interest in science but also helps prevent technophobia and math anxiety. It supports social and emotional development and builds resilience in the face of failure. Moreover, it is an effective tool in counteracting gender stereotypes in choosing career paths related to science and technology.

Why STEAM for sustainability?

To spark interest in scientific culture, we need inquiry strategies that lead to a deeper understanding of scientific concepts (Vilches & Gil, 2007). One of the most important goals of preschool education is to build children's intellectual readiness to learn. As recommended in *Science Education Now: A Renewed Pedagogy for the Future of Europe*, teaching

and learning should be renewed to encourage positive attitudes toward science and to rely on research-based methods (Rocard et al., 2007).

Through experiments, inquiry, and observations in the immediate preschool outdoor environment, issues of sustainability can be addressed in a practical way. The new curriculum aims to raise children's and teachers' awareness of environmental and climate challenges, such as conserving resources, reducing energy use, developing sustainable consumption habits, and fostering a healthy balance between technology and nature so as to achieve a sense of well-being. Concepts of sustainability structure the resources for teachers and teacher-trainers and call attention to the interrelationships among the three pillars of sustainability: environment, society, and economy.

Why outdoor education?

Outdoor education is often defined as “education in, about, and for the outdoors”. This definition captures the setting, the subject, and the purpose. Outdoor education can take place in any outdoor setting: from a schoolyard in an industrial neighbourhood to remote wilderness. It may happen on a walk around the block or in a forest, along a shoreline, at a lake, or in any other biome. Such locations are ideal for direct experience, contact with real phenomena, and rich social interaction.

Learning occurs through engagement with the outdoor space, and the subject matter weaves together holistic interrelationships between nature and people, attitudes of care for the planet, and skills for responsible use of natural resources. Six essential characteristics make outdoor education well suited to children's learning: it occurs outdoors; participants are directly involved; it uses real objects and phenomena; it helps learners connect facts and relationships; it engages as many senses as possible; and it invites active participation.

Why STEAM in preschool education?

STEAM education rests on five key components:

- Integration

- Practical application of knowledge
- Development of scientific thinking
- Collaboration
- Love of learning

Integration

Rather than teaching subjects as isolated areas of knowledge, STEAM activities are designed as project-based workshops that use inquiry-driven approaches with a strong emphasis on interdisciplinary learning. Consider the work of an architect: to complete a project, they must draw on mathematics, engineering, technology, various branches of science, and artistic inspiration. These elements are not separate from one another: they must be blended harmoniously in practice, enabling the architect to design complex buildings.

Practical application of knowledge

STEAM embodies the way we solve real-world problems. It offers a unique approach to teaching and learning by showing how knowledge can be applied immediately and purposefully in daily life. Think of a child building a cardboard bridge. How many questions must they answer, and how many problems must they solve, to make the structure strong? *What type of cardboard should I use? How should I put it together? What shape will work best? How can I make the bridge hold weight?* Activities like this help children understand the world better.

Development of scientific thinking

STEAM learning involves solving complex, meaningful problems that require perceiving, analysing, forming hypotheses, making predictions, observing, collecting data, and drawing conclusions. These skills form the bedrock of scientific thinking, which depends on logic and precision in making judgments about observed phenomena.

STEAM also nurtures creativity. When a child faces a challenge, such as building the tallest possible tower using only toothpicks and jelly-beans, or tackles an open-ended problem with no single correct answer, they practice flexible thinking. To pursue such activities, one must let

go of stereotypes familiar patterns, and allow a moment of “freedom”, embrace creativity and search for new solutions through trial and error.

Collaboration

STEAM education promotes teamwork and communication skills. Key aspects of collaboration include taking on both leadership and supporting roles, dividing and sharing tasks, and taking responsibility for completing them. During group activities, children learn to communicate, explain their ideas, consider different perspectives, and negotiate solutions. Imagine a group of children working on a project. Each approaches the task differently, bringing their own approach to solving problems. Yet together—by motivating and supporting one another—they can create an innovative solution that none could have achieved alone.

Love of learning

In today’s world, continuous learning is essential for personal and professional success. Students should leave school with a passion for learning; without it, they may struggle to adapt and grow in work and life. The STEAM approach is vitally important as it helps instil this passion from an early age. The greatest gifts we can give children are curiosity, self-efficacy, self-confidence, a thirst for knowledge, and a drive for growth. With these abilities, they will be well prepared to meet the challenges of higher education and the modern world—no matter where life takes them.

Why STEAM for sustainability in preschool education?

STEAM encourages students to develop solutions to real-world problems using knowledge and skills from science, technology, engineering, the arts, and mathematics. Although definitions vary, STEAM is most commonly described as an **interdisciplinary** approach to teaching and learning. When applied to sustainability, STEAM expands beyond interdisciplinary learning to encompass multidisciplinary, critical-thinking methods and sustainability-focused mindsets. Addressing complex, sustainability-related challenges requires both disciplinary expertise and

the ability to demonstrate and apply an interconnected understanding of these challenges through STEAM competencies.

What to consider when implementing steam teaching resources for sustainability

The resources presented here are intended for children aged 0–6. When developing them, several factors must be taken into account to ensure both the safety of the children and the conformity of what we propose with sustainability goals. It is also important to take into account children’s developmental characteristics as well as the responsible use and care of the environment.

Safety rules

Materials and learning spaces should spark children’s curiosity and encourage play, hands-on exploration, experimentation, creativity, and discovery. However, safety regulations must always be followed to guarantee that activities run smoothly and to prevent accidents (Branche et al., 2008; AENOR, 2008). Spaces and materials must be carefully selected to avoid hazards such as flammability, slipping, falling, dangerous substances, and sharp or unsafe tools.

All materials should be suitable for children to handle and should be in good condition and within their safe-use dates. In areas designed for adults—such as kitchens, laboratories, or non-adapted outdoor spaces—provision must be made for the presence of supporting adults. The materials must always be adapted to the motor, cognitive, and language abilities of the children for whom they are intended.

Sustainable materials and tools

In line with the goals of sustainability education through STEAM, resources should make use of sustainable and natural materials, as well as tools that do not harm or degrade the environment. Following the principles of sustainability, materials and tools should, whenever possible, be locally sourced, recycled, reusable, free, or very low-cost.

Include outdoor education

In keeping with the environmental pillar of sustainability, outdoor activities should be encouraged whenever weather conditions permit. These activities should promote observation, interpretation, care, and responsible use of the local environment. When conducting activities in different settings, flexibility is important with respect to climate, landscape, and culture.

Encouraging children to reflect on sustainability issues

One of the key mental processes that we aim to foster in children is thinking critically about their own experiences. The goal is to develop systemic, analytical, and synthetic thinking, always supported through dialogue. Questions should prompt children to search for answers in their own minds, and encourage them to be mentally active. Dialogue should focus on both cognitive skills—such as demonstrating understanding of an experiment—and metacognitive skills, such as making predictions, self-regulating, and self-evaluating throughout the activity.

What are STEAM for sustainability challenges?

STEAM challenges for sustainability are hands-on experiences designed to help children, independently or with adult guidance, build skills in observing, interpreting, managing, and conserving the environment. The core method is solving complex, interdisciplinary, real-world, open-ended problems—with no single “correct” or “ready-made” answer. These situations are intended to spark individual or group reflection and lead toward specific learning outcomes.

Unlike standard experiments or workshops, a STEAM Challenge:

- Provides general instructions for the activity but allows for multiple approaches. The objective, expected learning outcomes, and assessment criteria are clearly stated.

- Outlines the steps to follow and sets limits for action (e.g., materials to be used, space available, time allowed).
- Requires participants to think flexibly and creatively, without relying on ready-made answers or predetermined action patterns.
- Involves understanding the task, making predictions, and carrying out ongoing checks and reflections throughout the process.
- Introduces elements of competition, fun, and language use in a non-standard task structure that avoids questions like “How should we do it?” or “Could you explain?”
- Sparks curiosity and interest, energises participants, and brings a wealth of positive emotions that accompany play.
- Allows for diverse and original solutions—each response or design is unique, and adapting ideas to different contexts is encouraged.
- And most importantly, it makes learning joyful!

A STEAM challenge usually follows these stages:

1. **Planning:** Understanding and interpreting the task or challenge—for example, preparing materials, discussing the task, and clarifying understanding.
2. **Developing the experiment:** Building instruments or models using the available materials and tools.
3. **Presenting solutions:** Children present, compare, and test their different results.
4. **Documenting and reflecting:** Children describe their experiences in any form they choose, take photos, reflect on their solution, and assess its effectiveness.
5. **Summarising the discussion:** Asking questions such as: What have we learned? What proved to be the most difficult and why? What was the most fun?
6. **Extending the learning:** Using additional resources to complete the learning pathway and develop activities connected to the three pillars of sustainability.

What is a learning pathway?

A learning pathway is a structured sequence of learning opportunities designed to help learners Investigate, Develop, and Innovate. Activities in a pathway encourage children to explore and discover while developing the skills needed for innovative thinking and creative problem-solving. Learning pathways consist of logically ordered resources that guide children toward mastering a specific topic, scientific concept, or skill. They are designed to help learners move from everyday assumptions and common-sense ideas to scientific reasoning. A learning pathway is a flexible tool for teachers, allowing them to approach STEAM education as a long-term process rather than a single, isolated activity.

Why choose learning pathways instead of a single activity?

Learning pathways call attention to the importance of science process skills, the need to connect experiences through a central concept, and the role of mathematics, communication, and literacy in a science-based learning approach. The STEAM Cross-Curricular Pathway offers ways to incorporate Science, Technology, Engineering, Art, and Mathematics into teaching in a holistic manner, including—whenever possible—the three pillars of sustainability (economic, social, and environmental) or placing special emphasis on one of them. By exploring sustainable development goals, literacy, and more, this pathway helps educators discover the interconnections among all subjects while providing tools to foster inquiry, critical thinking, and problem-solving.

What types of learning pathways are included in our project?

We have developed two types of learning pathways:

- Pathways based on the spheres of nature: biosphere, hydrosphere, geosphere, and atmosphere.
- Pathways based on the seasons of the year: autumn, winter, spring, and summer.

How to use the project website?

We invite you to help young children develop sustainable habits and skills through STEAM and outdoor education approaches. You can use the website in several ways. On *KidsLab4Sust* you will find:

- Basic information about sustainability in preschool education, the STEAM approach, and outdoor learning, as well as ways to combine them in your teaching
- Detailed, easy-to-use resources for working with preschool children, using simple materials and tools
- Practical tips for conducting sustainability education in preschool and at home in ways that are engaging for both children and adults
- Ready-made scenarios for sustainability workshops in five languages
- Ideas for complete learning pathways with activities connected by a common theme: either the seasons of the year or the spheres of nature.

If you enjoy our ideas, you can join *KidsLab4Sustainability* as a co-creator by commenting on our proposals, sharing feedback, and contributing your own activities and educational pathways.

3.3. Pilot implementation of the preschool programme “STEAM Outdoor Education for Sustainability”

As part of the project, the partners organised short training sessions for interested teachers, kindergarten directors, and parents. Pilot studies were conducted in each of the four countries participating in the project. The aim was to implement the programme in kindergartens, assess the effectiveness of the teaching materials in practice, and collect feedback from teachers, children, and parents on the attractiveness and impact of the activities included in the “*STEAM Outdoor Education for Sustainability*” programme.

The research took place in ten kindergartens across four countries, with each partner signing a cooperation agreement with the participating institutions. The study involved 24 teachers (Poland–3; Spain–7; Ireland–3; Italy–11), 240 children (Poland–32; Spain–133; Ireland–32; Italy–43), and 79 parents who completed a survey (Poland–32; Spain–19; Ireland–13; Italy–15). The pilot lasted four weeks. Each group tested one selected educational pathway. Teachers implementing the pilot

independently chose the topics and materials, taking into account the children's age, abilities, and educational context.

Below are selected evaluation results studies from children and parents participating in the classes.

Overview of the pilot programme and findings from teacher-led classroom research

One example from the pilot programme took place at Municipal Kindergarten No. 10 in Jaworzno, where 20 children participated. The topics chosen by the teacher were:

- Who is a "climate refugee"?
- Experiments with ice (painting, making necklaces).
- Creating an edible ocean (dessert).
- Educational games about coral reefs and climate change.

When asked which activities they enjoyed the most, the children most often mentioned painting with ice on snow, creating an ocean dessert, making ice necklaces, the "True or False?" game about coral reefs, and the "bear fat" insulation experiment. The least enjoyed activities were watching a film about bears (due to its emotional content), the coding game, and painting with ice. In the latter cases, children struggled to complete the activity. During the classes, the teacher observed the children's behaviour and emotions. Joy, excitement, and enthusiasm were the most common responses, although some activities also triggered sadness and frustration, especially with more difficult tasks. The lessons additionally elicited empathy in the children toward animals, for example, polar bears.

The evaluation of the classes also examined the knowledge that the children retained. They were able to explain the concept of a climate refugee (using the polar bear as an example), the importance of protecting coral reefs and oceans, describe the properties of ice and bear fat, and identify pro-ecological activities such as waste segregation, resource conservation, and repair. Parents reported that their children applied this knowledge at home. In the study group, children suggested eco-friendly ways of getting to preschool (e.g., scooters, bicycles), repairing clothes

instead of discarding them, saving water and electricity, sorting waste, and collecting rainwater.

Results of parent evaluation surveys

After the classes, teachers asked parents to complete a survey. Parents observed six main types of reactions from their children. The most common was sharing newly acquired knowledge: children spoke about global warming, climate change, plants, and animals, often with great emotional involvement. Some even attempted to recreate the scientific experiments at home. In the parents' view, the most valuable developmental change was the shift in everyday habits: children began conserving water and energy, sorting waste, and using reusable packaging. Many also tried to influence the ecological attitudes of other household members, becoming "agents of change" in their families.

Despite teachers' initial concerns, the children quickly grasped complex concepts related to sustainable development and the "3Rs" (reduce, reuse, recycle), showing enthusiasm and a natural understanding of these ideas (Zdybel et al., 2024, p. 5). Parents also observed notable changes in their children's behaviour after the classes:

- Recycling: 100% of children reached the highest proficiency level (5).
- Water conservation: 90% of children at level 5.
- Desire to spend time outdoors: 80% of children.
- Empathy and sharing: noticeable in most children.

Conclusions

Based on the selected results cited above, we can conclude that the lesson plans developed by our team were effective in working with children. The short pilot programme engaged children emotionally and cognitively, inspiring them to become agents of change in their own environments. The positive responses observed by teachers and parents alike became a motivation to continue the activities and encouraged teachers to introduce "difficult" topics in the kindergarten setting.

The pilot study results presented above, although indicating positive outcomes, have limited cognitive value due to the small sample size (10 kindergartens and 240 children). As such, they cannot be considered

sufficiently representative, and drawing reliable conclusions about the program's effectiveness on a larger scale would be premature.

The program and its curriculum should undergo long-term evaluation, which is planned by all partner institutions. It is also important to emphasize that the program requires teachers to possess substantial knowledge and skills, as well as adequate staff preparation and infrastructure—conditions that are not met in all educational settings. Research conducted among teachers regarding barriers to implementation serves as a guideline for future actions. Partner universities are introducing training and workshops for both teacher education students and in-service teachers to enhance their competencies.

A long-term outcome of this project is the development of a syllabus and an online course for teachers, which is available to all interested parties. Further research and modifications to the children's program are planned, along with efforts to involve parents and local communities in educational activities.

Chapter 4

Curriculum for Preschool Teacher Education

Improving the quality of preschool education is closely linked to the need for changes in higher education. As part of the project, materials were developed to serve as a curriculum framework for training future teachers. The analysis of the action research and evaluation results from the *Preschool Education Program “STEAM Outdoor Activities for Sustainable Development”* formed the basis for creating four further outputs: (1) Recommendations for policy makers, (2) Curriculum framework for an academic course in the form of a STEAM syllabus for sustainable development, (3) Training manual for academic teachers, (4) Online course for educators in English.

Work on the outputs took place from February to July 2023 (the first three). The design, implementation, and evaluation of the English-language online course for teachers were carried out from January 2023 to May 2024. After receiving positive feedback on its content, structure, and materials, the course was translated into the partners’ national languages, uploaded to the *navoica.pl* platform, and made available through the universities’ educational platforms. The project team aimed to ensure open access for as many users as possible and to incorporate the training into teacher education programs, for example, through hybrid learning formats. Offering the online course in MOOC format also provides an opportunity for teachers’ professional development.

LUMSA coordinated the development of the core curriculum for academic-level teacher training. DCU proposed the structure and content of the training manual for academic teachers. All partners co-created, translated, and edited the content for each output. FPM developed and published the English version of the online course and prepared the

other language versions, while FI and UIK handled its implementation on the *navoica.pl* platform. The recommendations for decision-makers, published in English on the *Kids Lab 4 Sustainability* project website (<https://kidslab4sustainability.eu/recommendations-for-policy-makers/>), were prepared by the LUMSA project team. The purpose of this document is to promote the STEAM concept in preschool education as a key element in supporting sustainable development.

The main proposals outlined in this document are:

- incorporating the STEAM concept for sustainable development into the national preschool curriculum,
- providing teachers with appropriate teaching resources and the financial support needed to develop children’s competencies in this area, and
- including workshops on sustainable development, outdoor education, and STEAM in teacher training and professional development programs.

One of the key arguments for implementing these proposals is that STEAM education equips children with the skills needed to cope with future environmental challenges. Through the integration of science, technology, engineering, art, and mathematics, children gain a holistic understanding of the world. Inquiry-based learning encourages them to explore, experiment, and solve real-world problems creatively—an approach that should be prioritised in preschool education.

A practical example of these proposals in action is the *Kids Lab 4 Sustainability* project, which aims to improve the quality of early childhood education by implementing an innovative preschool curriculum, “*STEAM Outdoor Activities for Sustainable Development*.” The document emphasises that a crucial step in introducing such changes is strengthening the role of preschool teachers. This can be achieved by providing modern teaching materials and creating opportunities for knowledge exchange between preschools, universities, and policy-makers.

It is therefore important to educate “leaders of change”: teachers who will champion the STEAM approach in their institutions and incorporate the principles of outdoor education into their work. They will offer children experiences in natural environments that spark cognitive

curiosity and nurture environmental sensitivity. Examples from our preschool curriculum include identifying plants and animals, measuring elements of nature, and creating works of art from natural materials—activities that children readily embrace. Such activities support the development of natural and artistic competencies while strengthening children’s connection with the world around them.

Education for sustainable development can also be enhanced through cooperation with local organisations and, above all, with parents, who can consciously continue building sustainable skills at home. We also recommend creating a network of sustainable preschools and schools that integrate sustainable development principles through the STEAM approach and outdoor education. Many of these practices are already being implemented in preschools, as reported by teachers involved in the project.

The activities carried out under the *Kids Lab 4 Sustainability* project demonstrate that it is possible to create an inspiring educational environment that supports the development of future competencies from an early age. Introducing STEAM education for sustainable development at the preschool level is a key step in preparing children for a responsible life in harmony with nature.

4.1. Curriculum framework for the academic course: STEAM for sustainable development

This chapter presents practical solutions designed to support teacher education at the higher education level and professional development, in line with the recommendations outlined above. Based on an analysis of preschool and early primary education programs in the partner countries, it was concluded that there is an urgent need for a dedicated course on preschool teaching methodology: *STEAM in Education for Sustainable Development*. Each partner developed a syllabus in their national language, in accordance with the requirements of their respective universities. Below is a proposed syllabus for an academic course intended for students of long-cycle master’s programmes, which could,

for example, be offered as an elective subject at Polish universities. The content combines three areas covered in the materials presented in Chapters 2 and 3 and in the online course for teachers.

Course title: STEAM for sustainable development

1. Basic information

The course aims to provide students with fundamental theoretical concepts and main approaches related to education for sustainable development, outdoor education, the STEAM approach, and the role of learning through play. Consistent with recent empirical findings, the course also aims to equip participants with practical tools for application in early childhood education.

The course consists of 30 hours of synchronous classes, awarding a total of 3 CFU.

In addition to traditional teaching methods such as lectures and practical exercises, the course incorporates active learning strategies, including:

- STEAM challenges
- sustainability-focused experiments
- scientific observation
- inquiry-based learning
- visual note-taking
- storytelling
- the use of educational videos from the project website
- cooperative learning
- the project method

These methods are selected to develop key cross-cutting competencies related to sustainability, including:

- systems thinking
- anticipatory thinking
- normative competence
- strategic competence
- collaboration skills

- critical thinking
- self-awareness
- the ability to solve integrated, multidisciplinary problems.

2. Learning objectives

At the end of the course, students will be able to:

- Explain the main theories and models related to education for sustainable development, outdoor education, the STEAM approach, and learning through play.
- Analyse the developmental needs and tasks of childhood, with a particular focus on the role of play, especially in contact with nature, as a means of learning.
- Apply practical tools to conduct transformative education.
- Design and develop new learning units or learning pathways related to education for sustainable development.

3. Course rationale

This course provides students with both a theoretical and practical understanding of education for sustainable development, outdoor education, the STEAM approach, and learning through play at the preschool level, offering a holistic perspective.

Contents

Sustainable Development

The first module covers the fundamental theoretical models of environmental education and the framework of *Agenda 2030*. It also introduces methodologies and techniques for teaching sustainable development at the preschool level through hands-on activities, games, and storytelling.

1. Sample topics include:

- The concept of sustainability and its three pillars.
- The *Agenda 2030* framework and the Sustainable Development Goals (SDGs).
- Key UNESCO documents.

- Educational methodologies for achieving the SDGs.

2. Outdoor Education

The second module focused on the various ways in which outdoor activities can be used to support learning, personal development, and social engagement. It combines classroom-based learning with practical outdoor experiences.

Sample topics include:

- The origins of outdoor education (e.g., Montessori).
- The essence of outdoor education.
- Seven principles of outdoor education.
- Creating outdoor and indoor spaces (e.g., rewilding urban spaces, equipment, and materials).
- Community mapping.

3. The STEAM Approach

The third module focuses on ideas and activities for teaching STEAM creatively and playfully at the preschool level, using practical, hands-on activities and simple, accessible teaching materials. Examples include coding activities for children, construction and engineering projects, scientific experiments, STEAM challenges, and mathematical explorations using natural materials.

Sample topics include:

- Origins and meaning of STEAM education.
- Core STEAM skills: What they are and why they are important.
- Mindset for inquiry-based learning—workshops on different methods, such as:
 - (a) experiments
 - (b) observation
 - (c) STEAM challenges
 - (d) using ICT tools for inquiry learning
- Interdisciplinary learning—solving cross-disciplinary problems as part of the holistic STEAM approach
- Empowering teachers—valuing the learning process and experience as equally important as the outcomes

4. Teaching and Learning through Relationships

The fourth module examines the foundational role of social relationships in the educational journey of preschool children. It emphasises play as a dynamic, relational educational tool and highlights the ways in which teachers can strengthen their interactions with children.

Sample topics include:

- Socio-cultural theory of development.
- Pedagogical strategies for fostering attuned teacher–child interactions (*the pedagogy of play*).
- Self-assessment through video analysis.

Assessment

At the end of the course, students will be required to develop a learning pathway consisting of at least three learning units that encompass the concepts of sustainability, environmental education, and the STEAM approach, designed for application at the preschool level. This project will be completed in small groups. In addition, students are expected to study the course handbooks. The final examination will be oral and will assess students' knowledge of the course content, including the textbook, lecture slides provided to students, and the group project that they have produced. A passing grade requires a score of at least 18 out of 30. The maximum grade is 30, with honours awarded to students who demonstrate mastery of the course content, present their knowledge with coherence and clarity, and apply critical reflection.

Recommended readings:

- Brennan, C. (2008). *Partners in Play: How Children Organize Their Participation in Sociodramatic Play*. Dublin Institute of Technology.
- Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher*, 70(1), 30–35.
- Campbell, C., & Speldewinde, C. (2022). Early childhood STEM education for sustainable development. *Sustainability*, 14, 3524. <https://doi.org/10.3390/su14063524>

- Gaziulusoy, A. I. (2020). The experiences of parents raising children in times of climate change: Towards a caring research agenda. *Current Research in Environmental Sustainability*, 2, 1–8. <https://doi.org/10.1016/j.crsust.2020.100017>
- Gernhardt, S. (2004). *Why Love Matters: How Affection Shapes a Baby's Brain*. Routledge.
- Kernan, M. (2007). Play as a context for early learning and development: A research paper. *National Council for Curriculum and Assessment (NCCA)*.
- O'Dea, B. (2021). Minister warns of skill shortage in key STEM industries. *Silicon Republic*. <https://www.siliconrepublic.com/careers/minister-for-further-education-ireland-simon-harrisstem-skills-shortages>
- Sobel, D. (1996). *Beyond Ecophobia*. The Orion Society.
- PBS NewsHour. (n.d.). Why teachers need support to spur preschool STEM education. <https://www.pbs.org/video/why-teachers-need-support-to-spur-preschool-stem-education-1520380566/>
- Supplementary
- Dunphy, E. (2007). Supporting early learning and development through formative assessment. *NCCA*. The Stationery Office.
- Moyles, J. (2015). *The Excellence of Play*. Maidenhead: Open University Press.
- Sroufe, A. (2000). Early relationships and the development of children. *Infant Mental Health Journal*, 21(1–2), 67–74.

4.2. Training manual for academic teachers

The handbook presented in this chapter was developed by partners from DCU. It is based on the *EduHackathon* methodology, which brings participants together to solve a specific problem—in this case to establish and adapt the academic course described above to fit the training programme in each institution.

Kids Lab for Sustainability: Manual for Teacher Training

This handbook is designed to help you independently develop a course for students on outdoor STEAM education for sustainable development in kindergartens and schools. We invite you to join us in applying blended learning methods to create a learning environment in which students can both engage in hands-on, sensory STEAM activities related to education

for sustainable development and participate in an online course to deepen their theoretical knowledge and teaching skills.

We encourage you to adapt the course to the opportunities and constraints of your own teaching environment. The first part of the manual provides a framework—based on the hackathon methodology—for designing the course yourself. The second part offers sample materials (including a syllabus and educational resources) that outline the theoretical foundations, teaching content, and recommended literature, which you can use as building blocks in your own course design.

We wish you inspiration in your work and look forward to your feedback on the implementation of your ideas.

Introduction

Teaching how to teach is complex, to say the least. There is always new research, older approaches being revived, and constant changes in culture, funding, and society. A curriculum is ever-changing—just as its Latin root *currere* (“to run”) suggests. A curriculum moves forward, and it is up to us, as educators and learners, to keep pace with it.

The word “sustainability” is everywhere, but what does it really mean? Today’s children not only need to understand the concept but also have the right to know what sustainability means for them and for their future. This means that teachers need to be able to help children explore the complexity of social, economic, and ecological sustainability, its goals, and the cross-cutting skills that are required to achieve them. If children have a right to learn, teachers have a corresponding right to learn, and universities have an obligation to incorporate this important content into their existing programs.

So how do you, as higher education faculty, teach future teachers to teach sustainability? This handbook is intended to support educators at all levels—lecturers, assistant lecturers, professors, researchers, placement coordinators, and placement tutors—who are engaged in undergraduate or postgraduate early childhood education programs. Its purpose is to facilitate collaboration among faculty members in developing tailored approaches to integrating the *Outdoor STEAM for Sustainability* syllabus into their curricula.

All that is required is to gather your team for a two-hour session and ask them to bring their expertise, experience, ideas, values, optimism, realism, open minds, and energy. By the end of those two hours, you will have a clear, straightforward plan for incorporating the content into your programme without significantly disrupting existing modules. As an added bonus, this handbook can also be used to run a refresher session on collaboration and inquiry, which are two essential skills in both STEAM and sustainability education. By following the steps outlined here, you will create a plan tailored specifically to your students, program, department, and university, wherever it is located, because you designed it yourself. This is a sustainable approach to teaching sustainability, ensuring it resonates and endures in your context.

Methodology: Using an Edu Hackathon

Step 1) Inviting Guests & Logistics

Schedule a two-hour in-person meeting with your team. Also invite three master's and/or PhD students to serve as a panel of judges. Inform all stakeholders that the purpose of this gathering is to determine how, as a team, you will incorporate *Outdoor STEAM for Sustainability* content into your existing programme.

Provide lunch, or at the very least, coffee and snacks, to encourage maximum staff attendance. Ask team members to complete a short preparatory task before the meeting: finishing the four modules of the *KidsLab4Sustainability* online course: <https://kidslab4sustainability.eu/online-course-for-educators/>

For the meeting itself, divide your group into smaller teams of three or four members. Plan the group composition in advance to make the most of the collaboration.

Step 2) The day of the meeting—Welcome & Assigning teams

Welcome participants and explain that, as a group, they will work together to analyse a problem, propose potential solutions, and evaluate those solutions. Divide the participants into sub-teams and let them know they will be in a friendly competition. A panel composed of postgraduate students or other invited reviewers will choose the strongest pitch.

Contents of the Course

Modules: 4 **Lessons:** 12 **Total duration:** 02 h 37 min **Certificate of attendance:** fill in the evaluation form to receive it

> Module 1 - Sustainable Development (ESD) | 3 lessons - 39 min

> Module 2 - Outdoor Education | 3 lessons - 22 min

> Module 3 - STEAM as educational strategy in sustainable education | 3 lessons - 71 min

> Module 4 - Teaching and learning through relationships | 3 lessons - 25 min

> Evaluation form | **Receive your certificate**

Step 3) Defining the problem

Problem	Solution	Validation
<ul style="list-style-type: none"> - Who experiences this problem? - How common is it? - Where, when, and how does it occur? - Is it a local issue or a global one? - Is the problem urgent? 	<ul style="list-style-type: none"> - Brainstorm some new ways to solve the problem: <ul style="list-style-type: none"> • Using a low-tech product • Using an online platform • Through a community-based initiative - How can you connect the theoretical content to existing courses? - How can you embed the practical content in existing placement requirements? - How can you incorporate the content into assessments? - Describe how your solution would work for students. - Map out student journey: how do interact with it step by step? 	<ul style="list-style-type: none"> - Who else is trying to solve this problem, and how? - Which groups or individuals should be involved? (stakeholders) - How would you resource your solution (funding, staff, materials)? - Gather feedback from your target group: <ul style="list-style-type: none"> • Would they use it? • Why would they use it? - Do they have suggestions?

Finally, introduce the Hack Impact Canvas, developed by C. Keogh, R. Lyons, and D. Pollard (2021).

Step 4) Analysing the problem

Teams will have 30 minutes to analyse the problem and then present their findings to the group, using visuals if needed. Provide resources such as large sheets of paper, markers, and sticky notes. If the event is online, consider using a collaborative platform such as Mural.

Step 5) Guiding Productive Discussions

When teams share their analysis, take on the role of facilitator. Your goal is to guide the discussion constructively, ensuring that every team member's contributions are heard and considered. Engage actively by asking clarifying questions and encouraging deeper exploration of ideas. This will help maintain focus and energy making it more productive and ensuring that all potential solutions are thoroughly reviewed.

Step 6) Facilitating Solution Development

Allow 30 minutes for teams to develop solutions, and explain that they will report back to the group. When teams present their proposed solutions, help keep the momentum going by prompting discussion and encouraging constructive feedback.

Step 7) Validation process

Set aside 20 minutes for validating the proposed solutions.

Step 8) Ongoing Facilitation

During feedback sessions, check in on each group's progress to ensure the discussion remains active and productive.

Step 9) Evaluation of Pitches

The panel will have 10 minutes to evaluate the pitches and determine the most compelling solution, explaining the reasons behind their decision. The score sheet below can help you with the evaluation.

Score sheet for EduHack's hackathon

Please rate each criterion with points ranging from 1 (very low) to 10 (very high)

1. Name of the team:
2. Name of the jury member:
3. Scoring:
4. Comments and questions (optional):

Criterion	Points									
	1	2	3	4	5	6	7	8	9	10
Good idea										
Originality of the idea										
How feasible/doable the idea is										
The team's suitability to put the idea to practice										
Price to quality ratio of the idea										
Quality of the presentation										
Total										

Extension task

For all participants, including the panel:

Create an interactive PDF using tools such as Genially, Canva, or other similar platforms.

Task 1: Outdoor STEAM4Sustainability challenge

Choose the STEAM subject that you least enjoyed as a child—whether it was Maths, Art, or another area. Research and select a challenge that you can complete within a few hours, ideally one that takes you out of your comfort zone. This activity is not necessarily intended for young children. Examples might include collecting and documenting plant or insect samples from your garden, sketching them, gathering dry wood to build a fire using flint and steel, or constructing a shelter in the woods from branches. Document the process and write a 250-word reflection on whether, and how, the challenge helped build your confidence and skills in STEAM and sustainability.

Task 2: Explore your passions

Reflect on a genuine interest, be it baking, drawing, sewing, music, animal care, beachcombing, dancing, storytelling, coding, observing ants, or cultivating plants. This may be a passion from childhood, a newly discovered hobby, or a long-dormant interest. The key is that it is a genuine enthusiasm that truly captivates you. Write 250 words on how you could use that interest as the basis for a long-term STEAM for Sustainability project in an early childhood setting. Include in your interactive PDF photos of similar projects you found during your research. Write about how this project resonates with your personal values.

Team members then share their completed additional tasks.

Setting up the Eduhack working environment

How the venue is set up depends on the organiser's resources, the length of the event, and the number of participants. Ideally, each group should have its own room or private space. When that is not possible, partition the room or divide up the space so that each group has room to work.

Tools to support the process

Mentimeter, Kahoot, Mural, Prezi, and Miro are excellent tools for enhancing presentations, especially when gathering and displaying feedback and ideas. Mentimeter and Kahoot enable interactive polling and real-time audience engagement, making sessions more interactive and informative. Mural and Miro provide collaborative virtual whiteboards that allow participants to brainstorm and develop ideas together, whether or not they are in the same location. Prezi offers visually dynamic presentations that can capture attention and communicate complex information effectively. Used together, these tools make presentations more interactive, collaborative, and visually appealing.

The Kahoot! logo features the word "Kahoot!" in a bold, purple, sans-serif font.The Prezi logo consists of a blue circular icon with a grid pattern to the left of the word "Prezi" in a blue, sans-serif font.The Mentimeter logo features a stylized bar chart with a red bar on the left and a blue bar on the right, positioned above the word "Mentimeter" in a small, black, sans-serif font.The Canva logo is a square with a gradient from purple at the bottom to teal at the top, with the word "Canva" in a white, cursive font in the center.The Mural logo features the word "Mural" in a bold, multi-colored, sans-serif font where each letter has a different color.The Miro logo consists of a yellow square icon with a black 'M' shape inside, followed by the word "miro" in a lowercase, black, sans-serif font.

Choosing Winners Through Voting

Voting can be limited to in-person attendees or expanded to include online participants. The choice depends on your specific needs. Online voting requires a digital platform and the ability to host final presentations either in person or virtually via Zoom, Microsoft Teams, or a similar service. Since the goal is to undertake a shared task, broad participation in voting may be the most appropriate.

Regardless of the method, organisers should conclude the hackathon with a session in which each team is allotted time to pitch and present their ideas. This could take the form of a full-group presentation to all attendees or a virtual space where judges can view presentations and interact with teams. Participants should be informed in advance about the presentation format and the evaluation criteria. A standard presentation usually begins with a brief introduction of the team members and the problem they worked on, followed by an explanation of their solution, or a live demonstration, if appropriate.

4.3. Online course for educators: Description and evaluation results

In order to improve preschool teachers' skills, the project team developed a free online course titled *KidsLab4Sustainability*. The English version is available on the project website: kidslab4sustainability.eu/online-course-for-educators.

FPM handled the technical development and publication of the course, while the other partners prepared the content in line with the agreed topics, divided into four modules:

- Module 1 (UIC): Sustainable development.
- Module 2 (LUMSA): Outdoor education.
- Module 3 (FI/UIK): STEAM as an educational strategy for sustainable development.
- Module 4 (DCU): Teaching and learning through relationships.

Course objectives and structure

The course consists of 12 lessons, divided into four modules, featuring materials created in earlier project activities: mini-videos, lesson plans, and explanations of key concepts in sustainable development, STEAM education, and outdoor learning. It was posted on the project website (<https://kidslab4sustainability.eu/online-course-for-educators/>) and underwent an initial evaluation.

The course was designed to address the needs and challenges reported by teachers in the pilot studies. The objectives of each module are as follows:

Module 1: Sustainable Development

- Understand education for sustainable development from a holistic perspective.
- Explore the interconnections between the Sustainable Development Goals, the importance of ethics in decision-making, and the causes and consequences of social and environmental issues.
- Develop environmental awareness, promote sustainable practices through innovative strategies, and integrate education for sustainable development and global citizenship into curricula.

Module 2: Outdoor Education

- Explore the importance of outdoor education and learning both *through* and *in* nature.
- Learn about key pedagogical theories related to outdoor education and the avenues for incorporating it into the preschool curriculum.

Module 3: *STEAM as an Educational Strategy for Sustainable Development:*

- Learn about the STEAM approach and methods for developing children's scientific skills in practice.

Module 4 : Teaching and learning through relationships:

- Discover the value of relationships and play-based approaches in early childhood education.

- Learn methods for assessing and strengthening close relationships with children, using play as a pedagogical practice, and applying self-assessment tools that incorporate video analysis.

After consulting independent experts and running a pilot course with students and teachers from four countries, the course was revised. It was then translated into Polish, Spanish, Italian, and English, and made available in mid-2024 on the *Navoica* platform (https://navoica.pl/courses/course-v1:UniwersytetIgnatianumwKrakowie+KIDSLA-BEN02+2024_en_1/about) to make the course accessible to the widest possible global audience.

Evaluation results and training outcomes

Participants in every language version of the course on the *Navoica* platform could join discussions on education for sustainable development and outdoor learning. After completing the first two modules, they were invited to share their insights and experiences. This was one of the key elements of the training. Their statements were analysed qualitatively. In their contributions on education for sustainable development, participants pointed out five main themes, grouped into the following categories:

1. The role of the teacher as a role model.
2. Learning through experience and action.
3. Integrating education for sustainable development into the curriculum.
4. The need to build awareness and responsibility.
5. Community cooperation and involvement.

All participants agreed that teachers are—or should be—role models.

Many participants stressed the importance of daily eco-friendly habits as a practical way to care for the planet. They gave specific examples, including using reusable bags, bottles, and lunch boxes; sorting waste in kindergartens; saving water and energy; and reducing overall waste. They also drew attention to the importance of choosing eco-friendly teaching materials, such as recycled paper and non-toxic markers.

By cycling to work or encouraging children to take part in eco-friendly activities, teachers show that caring for the environment can be simple, while also setting a strong example:

Children learn best by imitation, so it is extremely important for teachers to model the attitudes they talk about in class. It is worth adopting eco-friendly solutions in everyday life. Simple eco-friendly steps—like having recycling bins in the classroom, encouraging healthy lifestyles, cycling to work instead of driving, or putting up informational posters—make a real difference.

Since children learn best through action and personal experience, participants suggested further ways of combining theory with practice and stressed the teacher's role in implementing experiential, action-based education. Examples included:

- Hands-on environmental projects such as starting school gardens, collecting recyclable materials, building insect houses and bird feeders, harvesting rainwater, and composting kitchen waste.

As teachers, we can support sustainable development by teaching children about caring for the environment, fairness, and responsibility. Through everyday routines, conversations, and by example, we help them build habits such as conserving resources, recycling, and cooperating with others. It is also important to involve children in projects that show that their actions really matter.

- Educational trips to parks, sewage treatment plants, or organic farms.

“Direct contact with nature and seeing real-life eco-friendly solutions are invaluable.”

- Interactive activities such as games, simulations, quizzes, and themed competitions.
- Special events such as Earth Day, Water Day, or Car-Free Day, where children can take part in workshops, performances, or community clean-ups.

“Let's get children actively involved in Earth Day, Water Day, or Car-Free Day by organising themed workshops, events, or neighbourhood clean-ups.”

Teachers also recognised that sustainable development should be embedded across all subjects. One biology teacher emphasised the value of an interdisciplinary approach:

In biology classes, we can talk about biodiversity and the effects of pollution; in geography, about global warming and natural resources; in chemistry, about pollution and green solutions. History can show how civilisation has shaped the environment, and social studies can discuss social justice and the circular economy.

They also recognised that sustainable development can be woven into the curriculum through various methods, such as case studies and research projects.

We should present children with real environmental and social problems, both local and global, and work together to find solutions. That way, we help them develop critical thinking skills.

Let's encourage small research projects, like measuring water use at home, tracking how much waste is produced, or exploring different energy sources.

For course participants, it was important to develop in children a sense of genuine impact on the future, along with awareness and responsibility for their own actions. At the same time, they stressed the need to point to concrete solutions, such as:

- Discussing values, ethics, empathy, social justice, and shared responsibility for the planet.

"Why does protecting the environment matter? What are the real consequences of human activity?"

- Conserving resources.
- Promoting conscious consumption and zero-waste principles.

"You can discuss where products come from, the problem of food waste, or organise clothing and book swaps."

- Recycling and waste sorting—why it matters.
- Highlighting the role of each individual:

"Let's remind children that even small, everyday choices can make a difference on a global scale."

Participants also pointed out that sustainable development requires joint effort, so it is worthwhile to build partnerships with parents and local organisations. Encouraging parents to take part in eco-friendly activities at home and at school reinforces children's attitudes and

habits. Suggested actions included holding open classes in kindergartens, running parent workshops, and involving schools in local initiatives such as forest clean-ups or creating green spaces in the city.

One course participant called attention to healthy lifestyles as an indispensable part of sustainable development:

Teaching about healthy eating, exercise, and mental wellbeing is also part of sustainability. Children need to understand how to take care of themselves because that helps them care for others and for the planet.

Overall, participants showed that they were familiar with the principles of education for sustainable development and aware of their role as teachers who can put these principles into practice. Importantly, most demonstrated the ability to link theory with practice and offered concrete examples of good practices in sustainability education.

Course participants' opinions on outdoor education

In a discussion on outdoor education, participants were asked to identify its advantages and challenges. They pointed to several benefits:

- helping children develop motor skills, creativity, and social connections,
- engaging all the senses,
- calming the mind through contact with nature (movement releases endorphins),
- improving knowledge retention,
- making the curriculum more practical and engaging,
- nurturing sensitivity to nature,
- meeting children's natural need for movement.

Teachers agreed that outdoor education has real value and said they would like to move more learning outside the classroom. At the same time, many admitted that practical obstacles often get in the way.

The main challenges they raised were:

- Location of the school: limited access to green spaces.

"Our school just isn't close to a forest or park, so trips into nature turn into a huge logistical undertaking."

- Weather: unpredictable conditions.

The weather can change in a heartbeat, which can make it difficult to organise outdoor lessons. If it rains, or it's boiling hot, or too windy, we have to rethink plans or move lessons inside. This requires flexibility and advance planning.

- **Safety:** the need for close supervision and preparation.

Organising outdoor activities means making sure safety measures are in place. Children need proper supervision, and the space must be safe for them. There is also some risk of injury during physical activity outdoors.

- **Resources:** lack of equipment, toilets, or proper clothing.

Outdoor learning often needs supplementary resources: sports gear, tools for building shelters, or materials for studying plants and animals. If the school doesn't have the resources, that's a real obstacle.

- **Logistics:** organisational difficulties and parental concerns.
- **Children's diverse needs:** different levels of fitness and interests.

Children have different levels of fitness, interests, and health needs, which makes it difficult to design outdoor activities that are suitable for everyone. In these cases, we need to adapt activities to fit each child's abilities.

- **Staff motivation and commitment:** reluctance to go outside
- **Children's motivation:** resistance to outdoor learning
Some children may not be interested in outdoor activities or may find it difficult to get involved. That's why it's so important for teachers to introduce them in a creative way and help spark their interest in learning outside.
- **Involvement of parents and the local community:** lack of trust, limited communication, concerns about children's health (ticks, insects, weather).

Parents often aren't ready for the extra laundry or for buying thermal clothes. And honestly, some staff don't enjoy going outside either—when they do, it's usually just to the playground.

Not all parents are comfortable with long trips beyond the school grounds, especially with younger children. This requires building trust and good communication with families.

Teachers from different countries reported similar challenges:

In Norway, outdoor education really boosts physical activity, well-being, and children's social skills. But the weather here is unpredictable, and the landscape is quite varied, so outdoor lessons aren't always easy. Teachers have to adjust their plans depending on the conditions. There are also different views among teachers on how outdoor learning should be done, which sometimes clashes with the school's expectations. Finding a middle ground is important. And of course, outdoor education requires teachers to have specific skills and knowledge.

In Azerbaijan, many schools lack outdoor space, equipment, or trained staff to provide effective outdoor education. In urban areas especially, there may not be enough well-kept parks or accessible natural spaces near schools.

Conclusions

Based on the participants' statements, we can conclude that:

- Teachers recognise their role in shaping children's attitudes toward sustainable development.
- Education for sustainable development should be practical, engaging, and woven into everyday life.
- Despite the challenges, outdoor education offers many benefits and is worth implementing when properly prepared.

The views expressed by the course participants support the recommendations developed by our team.

Online course evaluation

The course content was also evaluated through a participant survey. The majority (90% of respondents) gave positive feedback, saying that the course met their expectations. Since the course used English materials that were not translated into national languages, some participants noted that this posed difficulty for some (the automatic video translations did not work properly). They also indicated the need to include content for children with special needs and approaches to therapy through contact with nature.

Most responses conveyed the following views:

The course really expanded my knowledge, and I'd definitely welcome more courses on similar topics. Overall, it met my expectations.

The course was clear and to the point. I learned a lot and was able to refresh my knowledge.

A very good course that offers a chance to gain useful knowledge and teaching skills. It would be great if the groups of children in our preschools were smaller, which would make it easier to run experiments and other interesting activities. In practice, this is much more difficult, but even so, each lesson provides useful inspiration and you can try to incorporate at least some of it into your own classes. The topics were well chosen, approachable and interesting, presented at the end, which kept me eager to finish the whole course. Thank you for the opportunity to participate.

Conclusion and description of the social impact of the project

The *KidsLab for Sustainability* project focused on improving the quality of preschool care and education. It makes an important contribution to the ongoing discussion about education for sustainable development, a field whose concepts are often viewed as too complex or unsuitable for young children. Combining sustainability education with the STEAM approach and incorporating outdoor learning presents both challenges and opportunities for change at the levels of higher education and early childhood education. The project's activities can therefore serve as inspiration for future initiatives. As part of the project, teachers were introduced to key EU documents, including the *2030 Agenda* (UN, 2015), the *European Green Deal* (European Commission, 2021), the *European Pillar of Social Rights* (European Commission, 2023), and the *World Summit on Sustainable Development and UN Conference on Sustainable Development* (2019). In line with the *European Skills Agenda* (2021), preschools should focus on strengthening skills in young children that are important both for sustainable living and for their future career choices.

The preschool curriculum developed and disseminated by the team—*Outdoor STEAM Activities for Sustainable Development*—complements other initiatives and fills an important gap in early childhood education. It brings into focus the three pillars of sustainable development and not only introduces teachers to key concepts but also provides a wide range of innovative teaching materials. All of the educational resources included in the project's Repository accounted for multiple dimensions of sustainability: not only the environmental (which is the most common) but also the economic and socio-cultural. The Repository was built on theoretical foundations that combined two traditional perspectives:

the seasons of the year and the Earth's spheres. A notable innovation was the design of learning pathways that stressed the importance of long-term, repeated experiences for young children. Finally, all project materials were published as Open Educational Resources (OER), freely available to teachers, parents, and educators alike, thus serving as active tools for driving social change.

All project activities were built on collaboration, which not only supported the development of project outcomes but also helped strengthen the skills and competencies of the target groups. The involvement of preschool teachers, university staff, and students of early childhood and preschool education at every stage of the project enhanced their roles through knowledge sharing, exchange of experiences, and opportunities to co-create new teaching scenarios and evaluate materials developed by project partners (Szewczuk, 2024). These participants became change leaders in their communities.

Strong partnerships were created between universities, kindergartens, and local educational authorities. A clear example of social impact includes LUMSA's collaboration with the Fondazione Antonio Manes (Rome), which promotes outdoor education, and the city council of Porto Torres; UIC's cooperation with six preschools and schools in Barcelona (Bosquescuola–Learning in Nature, Dolors Montserdà Santapau–Public School, Canigó–Semi-private School, Vedruna Vall Terrassa–Semi-private School, School Isabel de Villena, and Ginebró School), as well as Escola Collserola and La Farga Institution in Sant Cugat del Vallès; and DCU's partnership with SLIGO Woodland School and *Inspiring Minds* Preschool. Ignatianum University in Cracow signed an agreement with the Małopolska Teacher Training Centre, through which it organised three teacher conferences combined with workshops on sustainable development, STEAM education, and outdoor learning. It also collaborates with kindergartens such as Radosna Chatka, Municipal Kindergarten No. 10 in Jaworzno, the Montessori Kindergarten in Skalbierz, St. Clare's Non-public Kindergarten in Cracow, and the Integrative Montessori Kindergarten in Cracow. Teachers from these preschools took part in workshops and carried out sustainability-focused activities

with children, which enhanced their own competencies and supported children's learning and development, as confirmed by research findings.

The preschool pilot programme had a strong impact on stimulating young children's interest in science, engineering, and mathematics. It also raised their awareness of climate change and motivated them to engage in pro-environmental activities. This was confirmed by feedback from both children and parents who participated in the pilot. Their voices were collected after the curriculum was introduced in preschools and then shared at an international conference and published (Zdybel et al., 2024). The results showed that even after a short 3–4 week pilot program, preschool children began acting as change agents in their families, explaining what they had learned to parents, insisting on small ecological changes in daily routines, and influencing the entire household.

From the perspective of universities, the shift in teacher education—from a primarily theoretical approach to a more practice-oriented one, initiated by the project partners—is expected to extend to new institutions that were not directly involved in the project. In the long term, this change will contribute to strengthening the professionalisation of the teaching profession, in line with current guidelines for early childhood education and care.

An innovative training manual for university faculty, based on the Edu Hackathon, has been developed to support this shift. To encourage collaboration and inspire university teachers to create their own manuals tailored to their institutions' needs, the project partners deliberately moved away from a traditional content-focused approach. In addition, a syllabus was designed for a new academic course, making use of other teaching and methodological resources, as well as an online training programme for teachers. Thanks to its flexible structure, users can select the content most relevant to their needs. The course promotes the STEAM approach and incorporates innovative methods such as the NASA engineering design model, STEAM challenges, and hands-on scientific experiments.

One of the most significant outcomes has been fostering teachers' motivation and sense of self-efficacy in the areas of sustainable

development and STEAM education, helping them overcome personal anxieties, particularly math-related fears. Many teachers struggle with “math phobia”, which directly affects their choice of teaching strategies and content. The project helped address these fears by presenting simple, accessible ways to integrate mathematical thinking into activities with children. Each scenario in the project’s repository encouraged critical, divergent, and scientific thinking in preschool classrooms, providing children with meaningful, interdisciplinary problems to solve.

Description of social impact: Summary

Social impact can be considered at local, European, and international levels. At the local level, the international team’s work produced the following changes:

- Teachers developed a new appreciation of outdoor spaces as essential, healthy, and natural environments that support children’s holistic development.
- Parents’ initially cautious attitudes toward outdoor education shifted, with greater acceptance of activities such as getting dirty or playing in natural environments as important elements in the development of children’s independence and self-regulation.

In addition, a vibrant learning community was created—bringing together teachers, researchers, and students—who collaborated, exchanged knowledge, and strengthened their competencies in this field.

All partner institutions established collaborations with kindergartens, schools, and organisations involved in teacher education and professional development.

At the European and international levels, the research contributed to:

- enriching national preschool curricula with proposals for outdoor STEAM activities focused on sustainable development,
- exchanging good practices and experiences among academic teachers from different countries,
- creating and disseminating teaching and methodological materials for teachers that take cultural diversity into account,

- developing an online course for teachers in multiple languages,
- sharing UNESCO documents with teachers, along with a list of interdisciplinary competencies that explain their importance in child development.

The KidsLab4Sustainability project primarily reached the following target groups:

1. students of preschool and early childhood education,
2. preschool and school teachers,
3. University faculty,
4. children and their parents,
5. decision-makers (preschool directors, local education authorities),
6. staff from teacher training and professional development centres (e.g., MCDN in Cracow, CESIRE in Spain, INDIRE in Italy).

Quantitative indicators of social impact include:

- number of children participating in the pilot studies: 240,
- number of parents who took part in the research: 79,
- number of teachers who tested the educational materials: 24,
- number of preschools involved in the pilot studies: 8,
- number of preschool directors who signed agreements for continued cooperation: 14,
- number of visits to the online course page on the project website: 931,
- number of visits to the project website: 72.041
- number of registered course users on the *navoica.pl* platform: 2,727 (from 28 countries worldwide, including: PL, ES, GB, AZ, TK, NO, IT, DE, CZ, NL, UA, FR, US, EG, EN, IE, AZ, MM, DZ, BR, IN, TR, GH, MX, BR, AM, PH, KZ),
- number of course completion certificates issued (*navoica.pl* platform): 511,
- number of evaluation surveys collected for the online course: 588;
- number of participants in dissemination events organised in four countries: 623,
- number of scientific articles published in journals and conference proceedings: 7,

- number of teachers participating in training within the learning community: 47,
- Number of Facebook page followers <https://www.facebook.com/KidsLab4Sustainability>: 881.

All of these participants strengthened their competencies in sustainable development and deepened their understanding of why and how to support children's growth.

An important long-term outcome of the *KidsLab4Sustainability* project has been the creation and strengthening of a network of kindergartens, teachers, and universities that promotes international exchange of best practices and experiences in promoting active learning in science and the arts in preschool education. This educational community has remained open and active after the project's completion. In addition, partners from all organisations enhanced their expertise in sustainability education and gained valuable experience in conducting international research and collaborative projects.

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