



STEAM Outdoor Education for Sustainability: a New Curriculum for Early Childhood Education

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Abstract

The "Kids Lab for Sustainability" project aligns with the European Commission's recommendations on "Key Competencies for Lifelong Learning" (2019) and the European Pillars of Social Rights (2020) by aiming to elevate the quality of Early Childhood Education and Care (ECEC) programmes. The project introduces an innovative curriculum entitled "STEAM Outdoor Education for Sustainability" which bridges the gap between sustainability as curriculum content and STEAM as a methodology for teaching and learning. STEAM, an acronym for Science, Technology, Engineering, Arts, and Mathematics, embodies a holistic, inquiry-based approach to learning, where children engage in solving real-life, interdisciplinary problems within meaningful contexts. This method not only fosters children's self-confidence and self-efficacy but also reshapes educators' perspectives, emphasising children's intellectual abilities over traditional academic achievements. The project worked to establish a collaboration between higher education institutions, preschools, and educational policymakers in different countries to support preschool teacher in acquiring new competences and improved the quality of ECEC pre-service training by integrating a "STEAM and Sustainability" module into university programmes, employing a blended learning approach to engage educators in hands-on experiences and online courses. Moreover the project developed a lot of innovative didactic materials available in 5 languages (EN, PL, IT, SP, Catalan) offered as Open Educational Resources (OER) on the project website. The project aims to provide teacher trainers worldwide with validated manuals and guidelines that incorporate STEAM methodologies. This initiative seeks to cultivate sustainable attitudes toward life and nature amongst children.

Keywords: Education for sustainability, STEAM, outdoor education, preschool curriculum, online course

1. The Role of Education for Sustainable Development in Kindergarten - Why Is It Important To Start Early?

The Brundtland report [1] has defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (p.41). But what are the problems facing sustainable development? There are basically three issues: overexploitation of natural resources; scarcity of these resources; and climate change. Therefore, humanity and the planet face unprecedented environmental challenges. In 2015, as a response to this growing threat, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development, a plan of action for people, planet, prosperity and peace [2]. The agenda incorporates 17 integrated and indivisible goals that encompass the three pillars of sustainability: ecological, social and economic. These three pillars must be considered in an interrelated way. Firstly, regarding environmental aspects, sustainability means protection and rational use of natural resources; it includes aspects such as environmental conservation, investment in renewable energy, saving water, supporting sustainable mobility, and innovation in sustainable construction and architecture, secondly social sustainability foster gender equality, development of people, communities and cultures to help achieve a reasonable and fairly-distributed quality of life, healthcare and education across the Globe and finally, economic sustainability means equal economic growth that generates wealth for all, without harming the environment, investment and equal distribution of economic resources with the final aim to eradicate poverty in all its forms and dimensions [3]. Consequently, sustainability is a complex issue, with edges in all areas of life. It can be said, metaphorically, that it is an "invisible" issue because it is not always easy to relate the causes to the consequences. For example, environmental degradation due to

climate change is a consequence of human actions which are the causes. This is one of the reasons for the need to implement education for sustainability in all educational stages, starting from the early childhood ages. As UNESCO [4] pointed out that Education for Sustainable Development (ESD) “gives learners of all ages, the knowledge, skills, values and agency to address interconnected global challenges such as climate change, loss of biodiversity, unsustainable use of resources and inequality”. It is vital to enable children to link human actions with consequences over the planet. The aim is to promote learning to live sustainably and at the same time to preserve the planet. The importance of education and training to address climate change is recognized in the UN Framework Convention on Climate Change (which entered into force in 1994), the Paris Agreement (adopted in COP21, 2015) and the associated Action for Climate Empowerment agenda [4]. The design of current early childhood education frameworks lay the foundations for children to develop intellectually, psychologically, emotionally, socially which offers “enormous potential in fostering values, attitudes, skills, and behaviours that support sustainable development” [5]. Moreover, the widespread integration of nature and ecology into teaching practices offers further support to children in refining sustainability competencies [6].

In UNESCO research, called “Teachers have their say. Motivation, Skills, and Opportunities to Teach Education for Sustainable Development and Global Citizenship” [7], more than 58.000 teachers all over the world opined over the importance of Education for Sustainable development and global citizenship education. Most teachers opined that climate change, sustainable consumption and production, human rights, and cultural diversity and tolerance were very important subjects to be taught. Nevertheless, one over four teachers did not feel ready to teach themes about sustainable development or global citizenship and peace. Research in this field, as Agut, Ull and Minguet [8] in the Spanish context, have pointed out the need to organise preliminary and continuous teacher training at the kindergarten level. Because of this challenge of empowering teachers, the project Kids lab for Sustainability was developed. This Project is in line with ESD and global citizenship education because it teaches children from a very early age to see the connections between our actions and the consequences to the planet and how each one’s actions can contribute to sustainability, enabling them to learn sustainable habits, because enduring habits are developed in such early ages.

2. Project aims and activities

Kids Lab for Sustainability is the result of cooperation between five European institutions: Ignatianum Foundation (Cracow, Poland), Universitat Internacional de Catalunya (Barcelona, Spain), Dublin City University (Ireland), Libera Università Maria Ss. Assunta (Rome, Italy) and Fondazione Politecnico Milano (Italy).

The primary objective of our project was to improve the quality of preschool education by introducing the new “STEAM outdoor education for sustainability” curriculum, accompanied by guidelines for educators and a collection of innovative, pedagogically tested educational materials. The curriculum integrates three major concepts of young children’s education: sustainability as a source of learning content (WHAT?), STEAM as a methodology of teaching and learning (HOW and WHY?) and outdoor as an educational environment (WHERE?). Although these ideas are not new to pedagogy, they are usually researched independently, and most researchers focus on school - aged children. Many researchers believe that developing competencies for sustainable development is too challenging or even unfeasible at the preschool level. Our project addresses this gap by recognising that young children possess immense learning potential, are naturally motivated, and are tirelessly curious, much like naive scientists [9]. As McClure et al. noticed, when young children enter school, “they already have substantial knowledge of the natural world, can think both concretely and abstractly, use a range of reasoning processes that represent the underpinning of scientific reasoning, and are eager, curious, ready to learn” [10]. Strengthening these abilities (encouraging scientific and sustainable mindset in children) should be seen as an important objective of preschool education.

The curriculum consists of three interlinked sections that complement each other (Ryc.; it is designed to be flexible and supplemental to national core curricula. The first section provides teachers with essential theoretical knowledge, explaining the links between education for sustainability, STEAM methodologies, and outdoor learning approaches. It shows the possibilities of using Inquiry based learning in developing sustainable competences in young children. These include systemic thinking, anticipatory competency, collaboration, critical thinking, self-awareness, normative competency to name but a few.). This section has been designed to encourage users to reflect and identify elements of STEAM and sustainability which already exist in their practice, although perhaps in an intuitive and non-verbalised way. Acknowledging the concerns many teachers have about teaching science and math, the project aims to boost teachers' self-confidence and sense of self-efficacy by offering simple, manageable activities for preschool children.



Pic. 1. The pilot of „STEAM outdoor education for sustainability” curriculum at the preschool in Jaworzno, Poland (Building bee houses in a preschool garden)

The second part of the curriculum called “Repository of Sustainability Learning Activities”, comprises over 500 lesson scenarios. These engaging and flexible educational resources are organised by the seasons and categorised under the Earth's spheres: Biosphere, Hydrosphere, Geosphere, and Atmosphere. The teachers can either select individual resources to adapt them to their lesson plans or follow a Learning Pathway developed by the project team for a more extended project. Learning pathways consist of a series of resources that are organised and logically sequenced to help children master specific topics, scientific concepts, or skills/competences. These pathways are designed to guide learners from initial preconceptions and commonsense knowledge to advanced scientific reasoning. Together with learning communities of in-service teachers in four EU countries we designed 30 learning pathways. For example:

- “Building Sustainable Relationships” - includes exploring neurobiological sources of emotions, learning the basics of self-regulation, and conflict resolution;
- “Circular Economy” introduces the concept of linear and circular economy, and develops the understanding of socio-cultural systems that follow the 3R principle: reduce, reuse and recycle materials;
- “The Force of the Earth” develops the knowledge and respect for natural phenomena such as earthquakes, volcanoes, tsunami; helps children to understand the biological processes behind them;
- “Rocks and minerals – under the magnifying glass of a geologist” develops the understanding of geological processes, allowing children to explore the qualities of different rocks.

While designing the learning resources we applied the multidisciplinary critical-thinking method to develop sustainability mindsets in young children. All materials are released under an open licence and are therefore reusable and modifiable.

The final section of the curriculum consists of the “Guidelines for Educators,” which details how to use the repository. It also explains how to develop their own learning resources

3. Pilot Study with Children

3.1. Pilot's Aims and Structure

The main objectives of the pilot study were: a/ testing the effectiveness of teaching materials in the educational practice; and b/ recognizing the opinions of teachers, children and parents on the attractiveness and effectiveness of STEAM for sustainability workshops. Each project partner signed the bilateral agreement with selected preschools, informed the parents and conducted the training for teachers willing to run the pilot with children. In general, 10 preschools participated in the study - Table 1. The pilot lasted 4 weeks, each group tested 1 learning pathway, and the topics were selected by the teachers themselves, adapting the materials to the age and cognitive abilities of the group of children, ensuring that the workshops were flexibly incorporated into the lesson plan.



Table 1. Participants of the pilot study

	Poland	Spain	Ireland	Italy	Total
Number of preschools	2	2	3	3	10
Number of teachers involved	3	7	3	11	24
Number of children participating	32	133	32	43	240
Number of parents responding to the survey	32	19	13	15	79

Due to the limited space, this article will only present select excerpts from parents' opinions. The central research question explored was: What are parents' views on the effectiveness of STEAM workshops focused on sustainability? Not all the parents answered the questionnaire. In total, we were able to collect the opinions of ... parents (32 from Poland, 19 from Spain, 13 from Ireland and 15 from Italy). Majority of respondents were females (only 3 males), age range from 28-64 (SD=38,9).

3.2. Method of Collecting and Analysing Data

The survey for parents consisted of 6 questions, out of which 2 were designed as open questions (and only these will be presented here):

- Your child's teacher has conducted some innovative activities in his or her classroom that combine the STEAM approach, outdoor education, and sustainability education. Has your child told you anything about these activities? If yes, what did he/she tell you?
- Based on your child's behaviour at home, have you noticed any changes in him/her after these activities at school? If yes, what did you notice?

Reflexive thematic analysis was used to search for common themes [11]. The list of codes is presented in Table 2.

Table 2. The list of themes and codes developed in TA (source: own design)

Themes extracted	Codes
1. Reporting the topic of workshops/ sharing knowledge with parents	Words related to telling: reporting, explaining Scientific concepts mentioned by the child e.g. Climate refugee, experiment, climate change, pollinators etc.
2. Feeling emotionally engaged/ concerned	Describing children's emotions: curious, excited, etc.
3. Repeating the experiments and activities in home environment	Mentioning children's actions e.g: doing, singing, showing, re-creating experiments, etc.
4. Demonstrating pro-ecological attitudes/ behaviours	Mentioning the changes in child's behaviours, such as: started sorting garbage, saving water and electricity, switching off lights etc.
5. Convincing the whole family to change their living style into more ecological	Mentioning children's actions such as: convincing to do sth/ arguing for/ reminding everybody



6. Actively searching for additional information

Asking questions, searching for new information in internet, wanting to know more about

3.3. Research Results

All the surveyed parents admitted that their children were eagerly talking about the content of the workshops. Six types of children's reactions were observed by parents - from the simplest, such as sharing new knowledge, through more complex emotional and cognitive reactions, to changes in children's everyday habits and attitudes. The most often observed reaction was reporting the content of workshops to families. Such reports were often accompanied by attempts to explain newly learned scientific concepts, share the acquired knowledge, and even expect additional information from parents, e.g.:

- Poland (PL): *He talked about what influences global warming and how we can all prevent these changes; He explained to me who a climate refugee is; He said that we must take care of the planet because it is the home of animals; He was fascinated by the Arctic and coral reefs. At home, we looked for various interesting facts about this topic on the Internet;*
- Spain (SP): *He drew a map of the world and explained things about the planets.*
- Ireland (IR): *Mira keeps going on about pollinators!*
- Italy (IT): *My son explained how the greenhouse effect works and showed us a simple experiment to demonstrate it. He was very excited about it and wanted us to watch it multiple times.*

Many parents noticed children's emotional involvement not only in the content of workshops, but also more broadly - a strong experience of threats related to global warming, empathic feelings towards plants and animals, e.g.: *We had an emotional conversation about environmental protection (...) From the first day, he talked about these issues with emotion; I noticed openness, enthusiasm and joy of discovery; I noticed great interest in the topics discussed. Willingness to share new information with parents (PL); My child was very concerned about the melting ice caps and wanted to know what we can do to help. She was sad about the plight of polar bears and very eager to discuss solutions (IT).*

Some parents also observed attempts to recreate scientific experiments at home, e.g. *"My kid wanted to recreate the experience at home. Was excited about the outcome of this experience" (PL); My daughter recreated a water filtration experiment at home using materials we had available (IT).*

The most developmentally valuable reactions observed by parents include changes in children's everyday behaviour in the home environment, i.e. spontaneously undertaken pro-ecological behaviours, e.g.:

- PL: *My son has become more "eco"; He started paying attention to turning off the water...; Turns off the water, turns off the lights, sorts the garbage;*
- SP: *He was motivated to recycle everything he sees at home; He takes more rational showers, he cares for a couple of plants, turns off lights, and recycle items; She shows more motivation and care for the environment;*
- IT: *My child now insists on using reusable containers and bags. He makes sure we separate our waste correctly. He has taken up the habit of turning off lights when leaving a room and reminds us to do the same.*

The most interesting behaviour observed by parents were the attempts to convince other household members to change their habits to more ecological ones. Children have become "change agents" influencing the entire family with their attitude, e.g.

- PL: *He argued for changing the car to an electric one; He encourages us to use reusable bags, donate or exchange unnecessary items instead of throwing them away; He turns our attention to sorting waste because we give it a new life... ; He says that we should take care of the planet (choose eco-friendly transport, eco-shopping bags, repair toys and clothes, and not throw them away);*
- SP: *He urges us to recycle more and wants to go to the recycling centre; She gave me a crazy proposal to save water (I'm not sure if it was using disposable plates to avoid using water to wash them, or something similar);*
- IR: *My daughter says I should use both sides of the page; When I throw away orange peels, he says we need to put them out in the garden to get the soil ready;*
- IT: *My son reminds us to bring reusable bags to the grocery store and even refuses to buy products with excessive packaging.*

Despite initial concerns from teachers that sustainable development concepts might be too difficult for young learners, parents in all countries noticed their children easily adopting scientific terminology and demonstrating a natural grasp of the 3Rs principle (reduce, reuse, recycle), essential for a circular economy.



The children embraced these concepts with enthusiasm, reviving traditional practices of resourcefulness that had been overlooked in a modern consumer culture

4. Conclusions

Even a brief didactic intervention of 3-4 weeks can have a significant impact. It has been shown to not only engage children emotionally and cognitively, but also to effectively foster sustainable competencies and attitudes. It can change daily habits, and increase awareness of their own effects on climate change. Children very quickly assumed the role of "change agents", convincing entire families to change their habits to more ecological practices, promoting changes in simple everyday behaviours, seeking additional information, and becoming emotionally involved.

Despite the teachers' initial fears, kindergarten children were not afraid of difficult topics related to climate change. On the contrary, sustainable workshops and scientific experiments conducted in a meaningful context inspired children to observe nature in a more conscious, sensitive and empathetic way. Thus proving that, as rightly noted by Nelson Mandela, education is the most powerful weapon which can be used to change the world because it has the ability to transform individuals, empower them to make more informed and sensitive decisions.

The experiences collected during the pilot were used to construct a curriculum for educating pre-service teachers. The following tools were developed within the project:

- KidsLab4Sustainability Online course for educators (<https://kidslab4sustainability.eu/online-course-for-educators/>) - freely accessible, self-paced and user friendly, addressed not only to teachers, but also to parents and other educators interested in education for sustainable development. The course comprises four modules: Sustainable development; Outdoor education; STEAM as educational strategy in sustainable education, Teaching and learning through attuned relationships. Each module is structured into three lessons, enriched by videos, animations, quizzes, and additional learning materials. The course can be followed without a predefined order allowing users to choose the content they need the most. Upon completion of the satisfaction questionnaire, a certificate of attendance is issued. The course is available in SCORM format, and it will be hosted on various e-learning platforms of the partners' universities which will integrate it into their curricula;
- Manual for teacher trainers supporting them in introducing the new subject into Early Childhood Education and Care programs at the university. The syllabus for such a course was designed with a choice of meaningful comprehensible literature;
- Recommendations for policy makers - indicating that the basis for the effectiveness of education for sustainable development is a broad agreement and involvement of the parties: parents, teachers, pro ecological organisations and local government authorities. Together we are responsible for the world we leave to future generations.

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