Hands-on in the School Pond!

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Abstract. The current sense of climate urgency poses significant challenges to the general population and, as a result, to schools. Environmental Education has a structuring importance in this context, taking into account its curricular transversality, focusing on the promotion of attitudes, values, and skills necessary to respond to the emergency situation revealed by several studies and international communications.

Natural Sciences curriculum guidelines emphasize the importance of science in everyday life, with applications in technology, society, and the environment. Problems/questions can emerge to guide learning when contextualized in real-life and current situations. They contribute significantly to the development of skills such as "reasoning and problem solving," "critical thinking and creative thinking," "scientific, technical, and technological knowledge and literacy" and "well-being, health, and environment" [1].

Active learning methodologies demand that students have direct contact with the phenomena that are to be investigated. Given that active engagement is required for understanding concepts and understanding the world, based on their experiences, it is important to note that verbal interactions alone are insufficient for developing metacognitive processes.

Students can interpret, substantiate, and build their own knowledge by encouraging investigative field/laboratory activities. With this in view, the Centro Ciência Viva de Braga (CCVB), Braga Ciência Viva Center's, developed activity "Pedagogical ponds" and "Creation and monitoring of pedagogical ponds" that has a significant impact on students who are involved and interact with this practical hands-on activity.

Keywords. Pedagogical Ponds, Environmental Education, Hands-on Activity, Natural Sciences.

1. Introduction

The concept of Environmental Education (EE) is relatively new, having been developed in response to a collective and increasingly global awareness of the need for a positive intervention for Nature and Sustainability as established at the UNESCO conferences in Belgrade back in 1975 and Tbilisi in 1977. At school, EE molds students into contributing members of society by instilling social values, attitudes, and knowledge centered on a single, but of utmost importance, concept: environmental conservation. The environment is regarded as a public good, essential to life and sustainability. Environmental education at school values not only environmental protection but also environmental recovery. Articulated actions for planning and promoting sustainable development should be promoted; it is within this framework that the school opens to EE. According to the Benchmark of Education for Sustainability [2], while the environment is a theme present in all curricular areas/disciplines of primary and secondary education programmes, namely Environmental Study, Personal and Social Education, Natural Sciences, Geography, History, Foreign Language, Philosophy, Chemistry, and Biology, its inclusion is not always defined explicitly and integratedly with the social/political and economic aspects involved. This referential emphasizes that in science-related programmes, an approach in which the established relationships between Science, Technology, Society, and Environment constitute the integrating matrix of the program's theme is favoured. This approach to integrated science education aims to leverage the development of essential skills that promote attitudes that recognise the significance of sustainable development.

The essential learning outcomes for the second and third cycles in Portugal are: students are able to characterize some of the existing biodiversity at the local, regional, and national levels, providing examples of relationships between flora and fauna in different habitats; identify invasive species of fauna and flora and their consequences for local biodiversity; and formulate critical opinions

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about human actions that condition biodiversity and the importance of its preservation. Furthermore they should: value protected areas and their role in wildlife protection [3]; systematize trophic chains of aquatic and terrestrial environments prevalent in the school's surrounding region, indicating forms of energy transfer; interpret trophic chains, beginning with various examples of food webs; critically analyze examples of the impacts of human action that condition the food webs, discussing measures to minimize them in ecosystems; discuss causes and consequences of ecosystem change, justifying the importance of the dynamic balance of ecosystems and how their management can contribute to achieving the goals of sustainable development; as well as to discuss options for the conservation of ecosystems and their contribution to human needs [4].

It is also highlighted the articulation of knowledge between other disciplines, such as in Physics-Chemistry, to explain the main conditions on Earth that allowed the development and maintenance of life, or in Geography, to characterize an ecosystem in the area surrounding the school (levels of biological organization, biodiversity) from data collected in the field; relate abiotic factors - light, water, soil, temperature - with their influence. Another requirement is that students be able to interpret the impact of some abiotic factors on ecosystems in general and apply it to examples from the school's surrounding area. Students should also be able to explain different types of biotic relationships and distinguish between intraspecific and interspecific interactions, and interpret information about population dynamics derived from biotic relationships and assess its implications for ecosystems [5].

CCVB pedagogical offer "Biodiversity of the Pond" and the project "Creation and monitoring of educational ponds" have a significant impact on the school environment, providing integrated implementation of field and laboratory activities in the approach to Natural Sciences and Environmental Education. This experimental approach provides an opportunity to develop scientific processes and investigative skills that can be transferred to other areas of knowledge while learning science content.

2. Characterisation of the "Biodiversity of the pond" and the CCVB's "Creating and monitoring educational ponds" project

i. Educational ponds scientific characterisation

Ponds are fragile and unstable ecosystems with high ecological value. They are critical for the survival of endangered animal and plant species, as well as for providing essential ecosystem services to humans, and thus are of great conservation interest. Ponds are permanent or temporary bodies of standing water or water with very low flow that are defined by the Ramsar Convention as areas of marsh, fen, peat, and or water, natural or artificial, permanent or temporary, with standing or flowing water, fresh, brackish, or salt, including marine waters, that do not exceed six meters in depth [6].

Ponds are one of the least known ecosystems, but they are also one of the most interesting and important, given the biodiversity that exists in such a small area. Because these biomes are very sensitive and are seriously threatened worldwide, it is critical to preserve and regenerate them. As a result, the CCVB has developed this educational offer for schools with the goal of raising community awareness of the importance of these ecological sites.

ii. "Pedagogical ponds" pedagogical characterisation

The activity is designed to increase students' understanding and awareness of the importance of preserving wetlands through field activities utilizing active methodologies in the CCVB space. This pedagogical offer is intended for all schools of any educational level that plan to visit the CCVB after making a prior reservation. This activity is approached using an inquiry-based science teaching methodology, identifying problems that stimulate research, debate, exploration, experimentation, observation, conclusion, and communication, all supported by research from an Inquiry Based Science Education (IBSE) perspective. Curiosity is sparked by encouraging students to conduct research and carry out all scientific procedures in an hands-on way. An analysis of the students' preconceived notions about the pond is

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performed, and a discussion of ideas is opened to verbalize them.

Figure 1. "Pedagogical pond" of Centro de Ciência Viva of Braga (CCVB)

iii. Creation and monitoring of educational ponds

The development and exploration of an educational pond as a teaching resource in a school setting aims to increase knowledge of biodiversity and the importance of these wetlands in the preservation and regeneration of local biodiversity. These habitats can support more biodiversity than rivers and lakes, as well as more rare and endangered species. It is also an important educational resource because it allows for the promotion of a variety of recreational and scientific activities that connect different disciplines and involve the school environment.

Some considerations must be made when building a pond, such as location, sun exposure, and orientation. The students are encouraged to handle and investigate all of the materials required for the construction of the pond, as well as to comprehend its physical characteristics. The screen used at the pond´s base must be flexible, able to accommodate any variation in the contours or movements of the soil, highly resistant to perforation, have a watertight membrane, and be resistant to ultraviolet rays. Following the screen, a net must be installed to allow the plants, as well as sand and stones, to be fixed. To protect biodiversity, the plants and animals used on the day of the pond's construction must be native species.

The Pedagogical Pond is created and monitored by CCVB biologists and ecologists, with financial support provided to the National Agency (Ciência Viva) at School Science Clubs (CCVnE) through the Human Capital Operational Program (POCH).

During the planning phase, the CCVB team of biologists visits the site to confirm the best conditions for the pond's implementation and to schedule the construction. This scheduling should ideally be coordinated with the Parish Council/Municipality for logistical support, equipment, and materials. Prior to beginning of excavation phase of the pond, all materials should be purchased. The dimensions of the canvas and netting are determined by the location of the pond. A pond should ideally have a surface area of $4m^2$ to $40m^2$, a maximum depth of 1m, and very gently sloping banks.

After digging the pond, a base must be laid to protect the screen, such as a geotextile blanket, cardboard, old blankets, or other material. The entire waterproofing structure (canvas) and the structure supporting the aquatic flora (shade netting) are installed in the next stage of pond construction. Once the entire structure has been stabilized, it is filled with running water, and water, plants, and animals are transported from an existing pond to the new ecosystem after a day. The CCVB biology team, as well as some students, employees, and teachers, are present during this phase to assist and monitor its execution.

Figure 2. Building a functional artificial pond

The pond ecosystem stabilizes after two months, and the phase of monitoring the physical and biological parameters of these spaces begin, as well as training students and teachers, particularly those involved with the CCVnE. Water samples are taken from the pond, and aquatic macroinvertebrates such as

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the water scorpion, water beetles, dragonfly larvae, mosquito larvae, ephemeroptera, cyclops, oligochaetes, ostracoda, and freshwater snails can be observed using binocular loupes.

3. CCVB's network of educational ponds

The Educational Ponds Network was launched in 2018 as part of the CCVnE programme in School Groupings/Ungrouped Schools, Professional Schools, and Private and Cooperative Education Establishments, with financial support provided by the Ciência Viva National Agency through the Human Capital Operational Program (POCH) fund. The CCVnE works in schools to provide open spaces for students to interact with science and technology, as well as to educate and provide generalized access to scientific practises, promoting experimental teaching of sciences and techniques. The CCVnE fosters collaboration between formal and non-formal education systems by forming strong partnerships with scientific and higher education institutions, municipalities, Ciência Viva Centers, R&D (Research and Development) companies, museums, and other cultural institutions.

Ten educational ponds were built or recovered in several schools throughout the region, with the goal of supplementing the activities developed in the curricular context using active methodologies.

Figure 3. Pond of Agrupamento de Escolas de Briteiros

4. Activities at the educational Pond

The implementation of recreational and educational activities based on solid scientific knowledge, as well as the investigation of its biodiversity and ecological processes, are central to the approach of this Environmental Education action.

It is critical for participants to reflect on and raise awareness about the conservation of these habitats (Wetlands), as well as the protection and preservation of local biodiversity.

Figure 4. Brainstorm with students before collecting the water sample for observations

Following a brief brainstorm, students proceed to the CCVB pond in order to collect water samples, which they will later examine and sort in the experimental laboratory. They learn to identify the invertebrates present in the water sample collected using Petri dishes, Pasteur pipettes, and binocular loupes/digital microscope.

Figure 5. Observation and screening for observation with digital microscope

The level of pollution can be classified by identifying the invertebrates present in pond water samples. Some species, such as ephemerals, Daphnia Magna, and dragonflies, act as bioindicators, meaning they are sensitive to pollution in the water. During the practical activities, students can take notes and identify the species in the pond by using identification guides or the internet. Water samples collected for laboratory analysis must always be handled with care and returned to the pond in the end.

Figure 6. Recognize the invertebrates with binocular magnifying lens (Ephemeroptera)

5. Conclusion

The activities developed within the "Learning Ponds" activities significantly improve theoretical content understanding and phenomenon explanation, as well as laboratory and field technique mastery. Learning becomes a metacognitive experience, according to Sá [7], when students are encouraged to develop a clear intentionality in their actions, becoming reflective in the planning, execution, and evaluation of activities. According to Piaget [8], children develop their way of thinking through interaction with the world around them. As a result, the use of active methodologies throughout the process adds meaning to the concepts addressed while also providing a clear representation of them. These processes are intended to improve learning quality and suggest a critical viewpoint by leveraging children's acquisition of certain scientific concepts.

According to Knoll [9], project involvement is a method for students to: i) develop independence and responsibility, and ii) practice social and democratic modes of behavior. The construction and monitoring of pedagogical ponds is based on active learning, in which students learn to connect theory to practice, and in which the student is the primary focus of the entire teaching-learning process. It achieves this by actively engaging students in the acquisition of knowledge, elevating the student to the role of protagonist in the learning process, and stimulating the search for knowledge through a hands-on approach.

The learning methodologies are strategically focused on engaging students in doing and thinking about activities, thereby involving them in their own learning. This type of project participation allows for the development of new skills such as teamwork, critical thinking, creativity, problem solving, communication, and project management [10].

Wetlands are disappearing dramatically. The loss or degradation of these ecosystems as a result of urbanisation, drainage, and intensive farming is linked to a significant decline in wildlife.

There is much we can do in our own schools, gardens, and communities to aid in the restoration and preservation of the ecosystem. Even a small pond can be an important ecological hotspot for biodiversity, attracting damselflies and dragonflies, as well as frogs and newts. It could also serve as a food source for birds, hedgehogs, and bats. One of the objectives of this lesson plan was to comprehend the significance of invertebrates such as water fleas, Daphnia magna, as bioindicators of invisible pollution and pond health. This crustacean is intolerant to pollution and toxicity and their presence means that the water pond is healthy and unpolluted. The students learned how to handle binocular magnifying glasses, and recognize some invertebrates such as Daphnia magna, dragonflies, aquatic beetles, aquatic snails, etc. It’s important to conclude that diversity is equal to healthy ponds and healthy aquatic systems.

A pond doesn't need to be big. Even a small pond can host more species than rivers and lakes. We can build a pond in home gardens and contribute to the increase of biodiversity and wetlands. It is also important to create pond networks between schools in the local area, between the community and to share their experiences using social media and digital tools. A pond is an excellent pedagogical resource to teach children and adults how a natural ecosystem works.

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