Agroforestry in the School – The Perfect Classroom

Constructionism, Environmental Literacy, and Biotechnology in a School in Brazil

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Abstract
This article demonstrates that agroforestry experiences transform relationships, stimulate critical thinking, and strengthen collective responsibility. The implementation of agroforestry at Casa Fundamental has proven to be a cornerstone for education that values students' connections with natural environments and relies on cultivating the land for holistic development. The projects "Backyard Forest" and "Our Agroforestry is Tech!" illustrate this approach: the former extended learning by bringing agroforestry to a retirement home, creating a productive and accessible environment; the latter mobilized design, technology, and biotechnology knowledge to develop an automated irrigation system, highlighting the interconnection between innovation and natural resource preservation. Investigations into natural patterns – such as fractal geometry and biomimetics – broadened students' mathematical perception, honed their analytical skills, and demonstrated that scientific inquiry can occur through art, technology, and sustainability.

Keywords and Phrases: Agroforestry, Constructionism, Environmental Literacy, Innovative Education, Biotechnology, Community, Project-Based Learning.

1. Introduction
Integrating nature, education, and community is an essential practice for everyone involved in education, especially at a historical moment when preserving life on the planet demands concrete actions of regeneration, care, and affection for life in all its forms of manifestation. In everyday institutional life, educators can and should invest in the convergence of constructionism, environmental literacy, and biotechnology, creating opportunities for a learning process that leads to the prosperity of students, the community, and the planet.

Casa Fundamental, a formal Brazilian school located in Belo Horizonte – the third largest city in the country – has been serving children and adolescents between the ages of 2 and 14 since 2018.

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What we present here is the result of the pedagogical processes developed at Casa Fundamental, which emerged from the relationship among the implementation of an agroforestry system in an elementary school, childhood, the constructionist approach, environmental literacy, and its dialogues with technology, art, and design. We will present the outcomes of two projects, and also a case study related to a teaching sequence we developed with two classes of the Early Years of Elementary School – children aged between 9 and 10 – over two years of experience with agroforestry at our school, from its implementation to the present day.

2. Agroforestry Systems: History, Implementation, and the Perfect Classroom

2.1 Principles of Agroforestry and Environmental Literacy

The agroforestry system fits within a broader vision of the symbiosis between agriculture and ecology, which aims to unite science, traditional knowledge, and low-impact agricultural practices. As a fundamental principle, agroforestry seeks to answer an urgent need: to produce in a sustainable manner while respecting the integrity of ecosystems and promoting the recovery of biodiversity and the preservation of natural resources.

For example, the extremely fertile soil found in the Amazon region is the result of agroecological practices long carried out by indigenous peoples who inhabited that region. These practices combined food cultivation with soil management and the maintenance of biodiversity. In this way, agroforestry is not a recent practice. It originates from traditional land management practices developed by various peoples throughout history, especially the indigenous peoples of Latin America.

Among the basic principles of an agroforestry system are: species diversity, plant consortium, intelligent use of space, and stratification.

Stratification, in particular, is the division of the vertical space into layers or strata, each occupied by plant species with specific heights, habits, and needs. The concept of stratification, as described above, originates from the agroforestry methodology developed by Ernst Götsch. As Götsch (1996) explains:

> This method, in essence, is an attempt to imitate nature, where multiple species live in association, depending on one another for their full development. In the same way, in agroforests managed according to this methodology, cultivated species are planted in consortium with others that are similar to those that would normally occur in nature. Also in accordance with natural processes, plant associations succeed one another in a dynamic and continuous process called natural species succession. *(Götsch, 1996, p. 3)*

The principles of agroforestry – such as species diversity, stratification, and natural succession – reflect a deep ecological intelligence rooted in both traditional knowledge and scientific insight. More than an agricultural technique, agroforestry serves as a living model of sustainability, where regeneration, production and environmental literacy are inseparably intertwined.

2.2 Implementation of the agroforestry system (SAF) in the school context

The timeline illustrated below traces the key stages in the implementation of the agroforestry system (AFS) within the school environment, from its initial planning in late 2021 to its current development. More than a sequence of events, it reflects the unfolding of a pedagogical project grounded in ecological awareness, community engagement, and long-term vision.

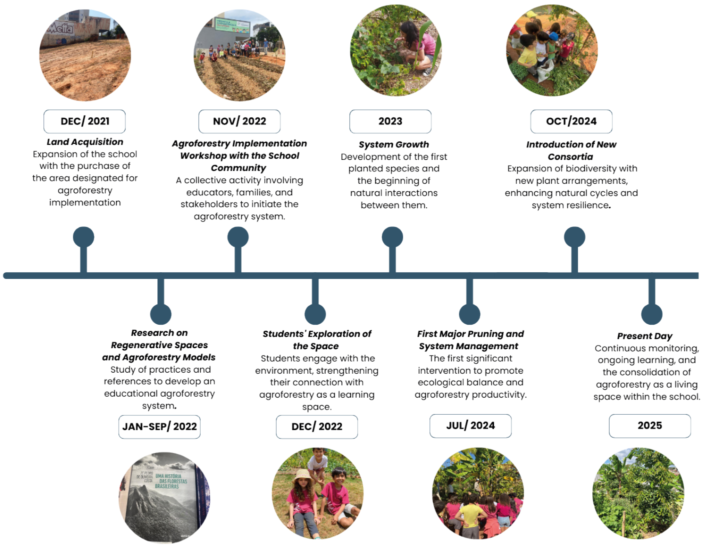

Figure 1: Timeline of the implementation of the agroforestry system (AFS) in the school context, from December 2021 to the present. Adapted from internal school documentation, 2025.

The initial challenge was significant: compacted and infertile soil that required careful and technical interventions to make it productive.

The soil preparation and planting reinforced the transformative role of the initiative and allowed us to experience firsthand the positive impacts of ecological regeneration.

Two years after its implementation, the school's agroforestry is productive. A forest is growing in the midst of an urban center in a city of the Global South, regenerating the soil, the landscape, the habitats, and human relationships.

2.3 The Perfect Classroom for the dialogue between Constructionism, Environmental Literacy, and Biotechnology

Planting an agroforestry is like planting rain. We heard this expression during the workshop that culminated in the implementation of the agroforestry in November 2022. More than an invitation to regenerate the soil, this idea reminds us that every intentional and well-planned action has impacts that go beyond the visible, creating cycles of abundance, care, and interdependence. In education, this metaphor translates into the need to cultivate a fertile environment for critical thinking, creativity, and ecological awareness, preparing children and adolescents to understand their relationship with the world and to positively influence their future. Just as in an agroforestry, where diversity strengthens the system and collaboration among species sustains life, contemporary learning should be based on multidisciplinarity, experimentation, and engagement with real challenges. After all, an education that ignores nature's time and rhythms is an education that dries up – and we choose to cultivate the rain.

The technical logic of agroforestry enables active, experiential learning through direct engagement with ecological systems. Understanding plant stratification – emergent to low – and its role in optimizing light, nutrients, and water introduces students to key concepts in biotechnology and regenerative biology. More than observing nature, it involves grasping processes like succession, carbon cycling, soil microbiology, and species symbiosis – foundations of sustainable agricultural innovation.

Thus, in a context where nature is the teacher, agroforestry is the perfect classroom.

Learning through cycles of planting, regeneration, and harvesting fosters awareness of the need for human systems to align with natural ones. This approach aligns with Orr's vision (1994) about the importance of a curriculum oriented toward sustainability, as well as the interdependence between nature and culture in learning.

In a complementary manner, the constructionist approach supports this active learning by emphasizing experimentation and problem-solving. Through land-based practice, students develop scientific reasoning and collaboration. Like agroforestry systems, learning communities thrive on diversity, cooperation, and shared agency.

3. Projects Based on a Constructionist Approach

3.1 Methodological Choices at Casa Fundamental

Casa Fundamental is based on pedagogical practices that value active learning, also founded on the principles of constructionism, and on its own exclusive methodology: 2E2C – Explore, Experiment, Create, and Share ('Compartilhar' in Portuguese). Developed specifically within and for Casa Fundamental, the 2E2C methodology structures investigative processes in which students and teachers are co-authors, and are involved in the development of a main artifact.

Among its pillars, the "share" stage stands out, as it reflects the idea that learning is not only individual, but deeply collective. As Ackermann (2001) explains, "Papert draws our attention to the fact that 'diving into' situations rather than looking at them from a distance, that connectedness rather than separation, are powerful means of gaining understanding." This perspective reinforces the values of shared learning, where the learning process itself emerges from interactions and layered dialogues – between students, among peers, and fundamentally, between the learner and the artifact. The artifact speaks: during its construction, through its sharing, and especially as it is revisited in light of the contributions and reflections that emerge from this collective process.

3.2 On the School Grounds: Project Practice Reports

The two projects presented here were developed in Elementary School classes, with children around 9 years old, over two years of experience in our agroforestry. The outcomes deal with the projects Backyard Forest and Our Agroforestry is Tech!.

In the Backyard Forest project, the class implemented an agroforestry system in a retirement home. The children participated in harvests and plantings in the school's agroforestry and applied their knowledge to the construction of an agroforestry system for a senior citizens' home. This project involved investigating concepts as well as planning and prototyping stages for a garden bed of medicinal herbs and tomatoes. The success of this initiative integrated the students into the agroecological process and expanded the impact of their discoveries to the community.

The initial challenge was to understand the needs and limitations of the residents in the retirement home, which led the students to develop a suspended planting system, replicating the agroforestry system in an entirely new environment and adapted so that people with reduced mobility could manage it appropriately. This experience allowed the students to apply design and sustainability concepts in a practical context.

The following year, the students deepened their investigations and identified the need to solve a problem noticed during the development of the previous project: the high water consumption by the school for irrigating the Agroforestry System (SAF).

In this context, the research aimed to automate the agroforestry irrigation process. For this, the students investigated the daily irrigation routine in the agroforestry to understand the ideal water volume for irrigation, the time required for this action, and the impact of both water scarcity and excess on some plant species in the agroforestry.

With the materials defined for prototyping, the students began the programming process for automation. In this stage, the micro:bit tool was used – a programming board that can be attached to the bits and that features an interface with a digital platform. Finally, they achieved the main objective: the sensor checks the soil moisture and predicts the irrigation schedule using the "check the time" function. If the moisture is low, the system activates at 10 a.m. and 4 p.m., which are appropriate times considering the region's sunlight incidence.

The class that developed the project had, as outlined by the BNCC (Brazil's National Common Curricular Base) in the field of Science, the goal of understanding the life cycle of plants, photosynthesis, and the relationship between living beings and their environment. However, the project's outcomes extended beyond these normative expectations. Through the experience, students explored soil composition, developed irrigation systems, and designed engineering strategies tailored to the needs of elderly populations. Furthermore, skills such as collaboration, empathy, and creativity were cultivated. As such, the project fostered learning experiences that surpassed curricular boundaries, enhancing students' autonomy and agency through socially meaningful practices.

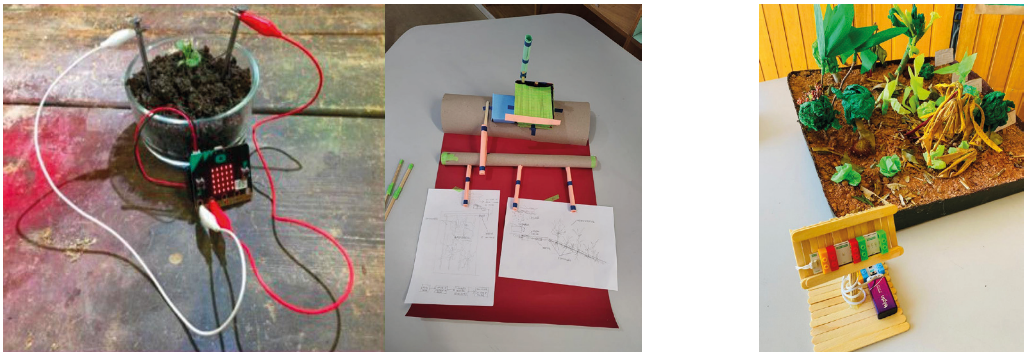

Figure 2: Photos 5, 6, and 7. Prototype 1 of the agroforestry irrigation system (left); Prototype 2, defining time and space for the system (center); and conductivity sensor test (right). From the authors' own documentation, 2025.

The table below presents a comparative overview between the skills prescribed by the BNCC for Science education and those also effectively developed by students throughout the project.

BNCC Science Skills	Skills Developed Through the Project
EF05CI02: Identify parts of plants and describe their functions, relating them to the food production process (photosynthesis).	Planning and implementation of a sustainable solution (suspended garden), integrating knowledge of engineering and accessibility.
EF05CI03: Understand the importance of photosynthesis for living beings and environmental balance.	Development of empathy and social responsibility while working in a collective space (elderly care home).
EF05CI04: Investigate the life cycle of living beings, recognizing patterns and variations.	Understanding the operation of irrigation systems and efficient water use.
EF04CI03: Identify relationships between living beings and the environment in different ecosystems.	Collaborative work and problem-solving in teams, organizing planting spaces and materials, and documenting the process using multiple forms of expression (reports, photos, videos).

Table 1: Comparison between BNCC skills and those developed through the project. Adapted from internal school documentation, 2025.

Above all, the experience revealed that through everyday school practices, we found the source, inspiration, technique, and conceptual grounding to design our own curriculum – rooted in reality, guided by purpose, and responsive to the world around us.

3.3 Case Study: Fractal Geometry and Biomimetics

The case study on fractal geometry and biomimetics revealed the potential of these themes for fostering curiosity and investigative thinking among children through the observation of the natural world. From this, we came to understand the relevance of developing a specific curriculum for agroforestry projects. The inclusion of this case study in this article is justified as a concrete example of the articulation between everyday pedagogical practice – rooted in the daily realities of basic education – and curriculum development: real outcomes of the impact of research on environmental literacy and constructionism.

Furthermore, the sequence was inspired by the principles of natural computation, an interdisciplinary field that uses nature-inspired algorithms to solve computational problems. Natural computation is relevant to several emerging areas, such as biotechnology, artificial intelligence, and data analysis. By exploring these concepts in a living and dynamic environment like agroforestry, students had the opportunity to discover possible connections between the natural world and contemporary technological fields.

In the agroforestry, students identified and investigated geometric patterns present in leaves, branches, and roots – observing fractals and exploring concepts of biomimetics, which enhanced their visual perception and analytical capacity. Next, inspired by natural forms, they created stamps during Creation Lab classes, promoting an integration of science, art, and technology. Finally, they used the Scratch platform to digitally model these patterns, deepening their understanding of algorithms and computational modeling.

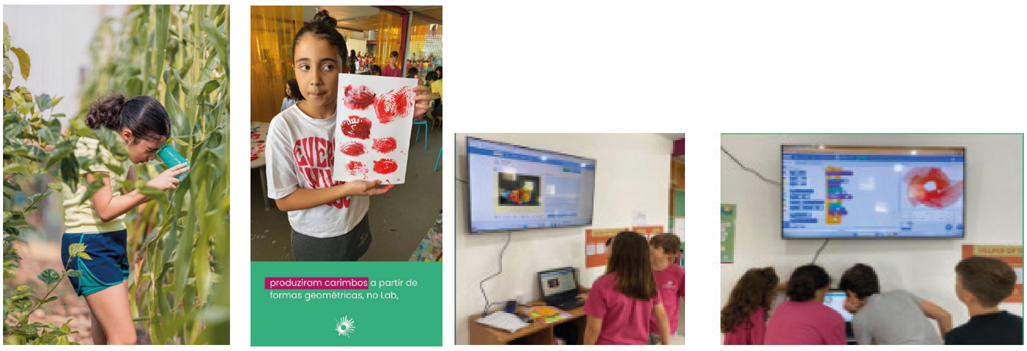

Figure 3: Photos 8, 9, 10, and 11. Observation and investigation in the agroforestry system (left); artistic expression and design (middle); and computational modeling and programming (Photos 10 and 11, right). From the authors' own documentation, 2025.

By engaging daily with the living context of an agroforestry system, we encounter a real and complex learning environment – one that naturally demands investigative approaches. This setting allows for an authentic articulation between the lived experience of natural phenomena and the constructionist perspective. It is through this grounding that theoretical concepts gain validity, enabling the development of a situated, real, and epistemologically robust educational experience.

4. Conclusion: New Learning Horizons

The experiences described in this article demonstrate that engaging with agroforestry transforms relationships, fosters critical thinking, and reinforces collective responsibility. Establishing an agroforestry system in a school – and within an urban context – regenerates physical space, and also the way we understand human relationships and education.

Agroforestry thus emerges as both a strategy for environmental regeneration and a powerful driver of educational and social transformation. By integrating diverse fields of knowledge, it frames problem-solving as a process inspired by life's inherent intelligence. In a complex and uncertain world, the most abundant source of learning and creativity is not digital technology, but nature itself.

In this context, the articulation between agroforestry as an educational space and the constructionist approach reveals a profound conceptual convergence, anchored in the notion that the learning process simultaneously involves the construction of knowledge objects and the self-construction of the subject.

Through its ecosystem relationships, nature teaches us adaptation, collaboration, resilience, and innovation. It offers solutions that are sustainable, regenerative, and deeply embedded in the web of life. Observing natural systems inspires the creation of approaches that honor interdependence and complexity.

Agroforestry – the perfect classroom – inspires us to project desirable futures, inviting us to look at the very logic of life and recognize that the answer to contemporary challenges may lie in the way nature has always known how to exist.

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