Pedagogical Strategies for Renewable Energy Education in Elementary Schools

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Abstract

The energy sector and the energy transition are central issues in global debates. Education also plays a key role in finding solutions to sustainable development, and when initiated in childhood, this education process helps form more conscious citizens. This paper presents pedagogical strategies developed by the project Sustainability is a Child's Matter, with a focus on renewable energies, such as development of materials in a child and youth-friendly language, gamification, hands-on experiments, interactive activities and training for teachers. Since its beginning, in 2023, the project has already served more than 600 elementary school students from different schools in Florianópolis, Brazil, and provided training to 43 teachers. These activities help to minimize gaps highlighted in literature, like lack of teaching materials, limited time for teachers to prepare materials and the absence of partnerships with existing projects. Moreover, the project aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 4, SDG 7 and SDG 13.

Keywords: renewable energies, education, elementary schools, SDGs

1. Introduction

The energy sector has become a central theme in current global debates, particularly due to the urgency of redefining production and consumption models based on principles of sustainability (Farias et al., 2021). It is well known that the construction sector is among the most resource-intensive industries and that buildings are responsible for consuming large amounts of energy throughout their life cycle. Furthermore, energy consumption is closely linked to greenhouse gas (GHG) emissions. Although Brazil reports one of the lowest GHG emission rates worldwide, due to its predominantly clean energy matrix, with 50.0% from renewable sources compared to the global average of 14.3% (EPE, 2025), rising energy demand contributes to climate impacts and to the ongoing energy crisis.

During a building's life cycle, the use, operation, and maintenance phase is both the longest and the most energy-intensive, offering the greatest opportunities for user intervention. As Janda (2011) notes in *"Buildings don't use energy: people do"*, reducing building energy demand depends not only on design or efficient equipment but fundamentally on user behavior.

Children and adolescents, often overlooked in this discussion, play a crucial role as agents of change and knowledge disseminators within families and communities (Lucas et al., 2024). Education, therefore, is key to addressing environmental challenges, driving energy transition, and fostering sustainable development (UNESCO, 1997; Tilbury et al., 2002).

When initiated in childhood, this learning process contributes to raising more conscious citizens by encouraging critical reflection on the values and perspectives of the society which we live in (Davis et al., 2024). Thus, incorporating energy education from the earliest years of schooling fosters a new generation

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better prepared for the energy transition and the challenges of the climate crisis, emphasizing the importance of children's active participation and leadership in building sustainable solutions.

Elementary Education in Brazil is guided by the *Base Nacional Comum Curricular* (BNCC), a normative framework that defines the core content of school curricula. One of BNCC's stated objectives is to enable students to develop a new perspective on the world, acquire critical thinking, and make conscious choices based on sustainability and the common good (Brazil, 2018). This provides a strong starting point for disseminating energy education. However, although BNCC includes renewable and non-renewable energy topics, their treatment in schools is often fragmented and superficial (Bremm and Gullich, 2018). Studies also highlight challenges such as the scarcity of teaching materials, the limited time teachers have to prepare them, and the absence of partnerships with existing projects (Severo and Fossati, 2025), all of which undermine students' engagement with the subject (Leff, 2009; Saviani, 2009; Lima and Pato, 2021).

A practice often highlighted in the literature on sustainable and energy education is the use of green buildings as pedagogical tools, employing the physical infrastructure itself as an educational resource. Such buildings provide opportunities for students to understand concepts in real terms, as they can directly observe the application of renewable energy, energy efficiency measures, and resource reduction practices (Cole, 2019; Khofi, 2024). However, the mere presence of infrastructure is not enough (Pearce, 2016); it must be actively integrated into pedagogical activities and the curriculum (Zangori and Cole, 2019; Ott et al., 2018). Daoudi (2024) argues that education in renewable energy is essential to achieving the 2030 energy transition goals. Without quality education across all school levels, combined with community engagement and adequate teacher training, many objectives related to clean energy, climate change mitigation, and sustainable development remain at risk. As pedagogical methodologies and learning tools, the author highlights traditional classroom instruction, experiential learning, digital tools, and technologies such as interactive media, online resources, simulations, and teacher training, ensuring not only updated knowledge transmission but also meaningful learner engagement.

Complementing these findings, Chen et al. (2023) analyzed international studies conducted in the United States, China, and Europe, which show that education is crucial for reducing the consumption of non-renewable energy sources and promoting the use of renewable ones, indicating that education contributes directly to lowering overall energy use. These results demonstrate a clear relationship between knowledge levels and awareness of energy use, leading to positive impacts on reducing dependence on traditional energy sources. The responsibility for disseminating sustainable practices in primary education lies mainly with teachers, who, by addressing global sustainability challenges and fostering understanding, stimulate students' interest in responsible alternatives, thereby encouraging stronger environmental commitment in the future (Kandpal and Broman, 2014).

Since childhood is the stage when the learning and discoveries that shape life-long values begin, and because today's children will become the agents capable of slowing and reversing environmental impacts (Müller and Silva, 2023), strengthening the debate and teaching of renewable energies in classrooms from the earliest years is increasingly necessary. It is therefore vital to disseminate interdisciplinary approaches that introduce children to concepts of clean and renewable energy to cultivate collective awareness regarding the responsible use of natural resources. To this end, it is essential to create and improve initiatives dedicated to renewable energy education, addressing its environmental, social, and technological dimensions, particularly for children and adolescents.

In this context, the project *Sustentabilidade é Coisa de Criança* (Sustainability is a Child´s Matter), developed at the Department of Architecture and Urbanism of the Federal University of Santa Catarina (UFSC, 2025), introduces sustainability in the built environment to children through playful, curriculum-aligned activities. Its actions include: (1) development of child-friendly teaching materials based on BNCC; (2) delivery of classes, workshops, and lectures in schools; and (3) teacher training. Beyond theoretical approaches, activities integrate games, discussions, and exercises across six themes - energy and atmosphere, water, land use, transport and accessibility, materials and resources, and indoor environmental quality - linking environmental, social, economic, and cultural dimensions.

This article presents the educational strategies developed by the project, with a focus on renewable energy. Through workshops and playful activities using educational materials designed in accessible language for

children and adolescents, the project seeks to foster their engagement with the principles of energy sustainability, encourage understanding of different renewable sources and stimulate conscious practices in both school and family contexts.

2. Methodology

A bibliographic review was carried out on renewable energy and also an analysis of the contents of BNCC from 1st through 9th grade of Elementary Education. It was identified how, where and in what depth energy sources, renewable energies, greenhouse effect and global warming are addressed (Table 1).

Table 1. BNCC contents on topics related to renewable energy (adapted from Brazil, 2018)

Discipline	Grade	Knowledge Objects	Skills
Geography	3rd	Impacts of human activities	(EF03GE10) Identify the necessary precautions for using water in energy generation to ensure the maintenance of the supply of drinking water.
Geography	5th	Work and technological innovation	(EF05GE07) Identify different types of energy used in industrial, agricultural and extractive production and in the daily lives of populations.
Science	5th	Physical properties of materials Water cycle	(EF05CI02) Apply knowledge about changes in the physical state of water to explain the hydrological cycle and analyze its implications for agriculture, climate, electricity generation, the provision of drinking water, and the balance of regional (or local) ecosystems.
Science	7th	Simple machines Heat transfer History of fuels and heat engines	(EF07CI05) Discuss the use of different renewable and non renewable energy sources, thermal machines and their applications.
Science	7th	Greenhouse effect Ozone layer	(EF07CI12), (EF07CI13) and (EF07CI14) Explain air composition and its importance for life, addressing the greenhouse effect and ozone layer.
Science	8th	Energy Sources Energy Transformation Calculating Electricity Consumption Conscious Use of Electricity	(EF08CI01) Identify and classify different sources (renewable and non-renewable) and types of energy used in homes, communities, or cities. (EF08CI04) Calculate the consumption of appliances to assess the impact of each device on monthly household consumption. (EF08CI05) Propose collective actions to optimize the use of electricity in the school and/or community, based on the selection of equipment according to sustainability criteria (energy consumption and energy efficiency) and responsible consumption habits. (EF08CI06) Discuss and evaluate electricity generation plants (thermal, hydroelectric, wind, etc.), their similarities and differences, their socio-environmental impacts, and how this energy reaches and is used in your city, community, home, or school.

Based on this research, teaching materials were developed to help disseminate knowledge about renewable energy and facilitate access to quality materials for teachers. Among the teaching and pedagogical materials developed are slides for expository classes, games, exercises, and playful activities, covering different levels of complexity, to be used in different grades of elementary schools. Using the developed material and renewable energy generation models, classes and workshops were held for children and teacher training was

provided. A website was created to support the project, where all materials are available for free download (UFSC, 2025).

3. Results and discussions

The analysis of the *Base Nacional Comum Curricular* (BNCC) regarding energy sources, renewable energy, the greenhouse effect and climate change indicated that these contents are addressed mainly in Science and Geography. In the 3rd grade, the study of water in energy generation begins, reinforced in the 5th grade. In the 7th grade, discussions focus on renewable and non-renewable fuels used in machines, as well as the greenhouse effect. However, it is in the 8th grade that the debate intensifies, with more in-depth study of energy sources and energy production for households, communities, and cities.

Based on this analysis, teaching materials were created to support classroom activities (Figure 1). The first, *"Energy Sources"*, presents renewable and non-renewable sources, highlighting the main resources used for electricity generation and their share in Brazilian consumption compared to other countries. This reinforces Brazil's prominent role in clean energy use. More detailed lessons were then developed on the main renewable sources used in electricity generation in Brazil: water, wind, and solar. These materials explain the operation of each system, the technologies involved, and applied examples, fostering environmental awareness and stimulating children's interest in sustainable energy solutions.

Additional lessons, such as *"Me vs. Energy and Atmosphere"* and *"Greenhouse Effect vs. Global Warming"*, highlight the relationship between energy consumption, emissions, and climate change. These activities encourage reflection and discussion, raising children's awareness of their own consumption while presenting behavioral alternatives grounded in environmental responsibility. These lessons symbolically explore the connection between the individual and the planet, reinforcing the importance of preserving the collective environment. Special emphasis is placed on reducing energy use, promoting efficiency in the built environment, and expanding the adoption of renewable sources, encouraging responsible attitudes from an early age.

Fig. 1. Materials prepared for classes (UFSC, 2025)

As a complement to the theoretical material developed, gamification strategies were used to fix the renewable energy contents in a playful way. They aim to enhance knowledge and encourage children to reconsider their energy consumption habits. Examples of these activities are the Wind Energy Memory Game (Figure 2), word search (Figure 3), crossword, fill-in-the-blank, coloring activity (Figure 4), origamis, Renewable Energy *Uno* (Figure 5) and Sustainability Bingo (Figure 6). These diverse tools aim to adapt the content to child-friendly language in different levels of complexity, stimulating interest and student participation from all grades of Elementary School.

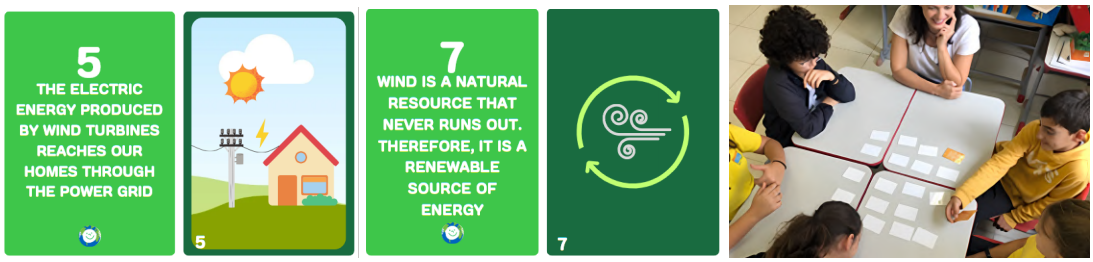
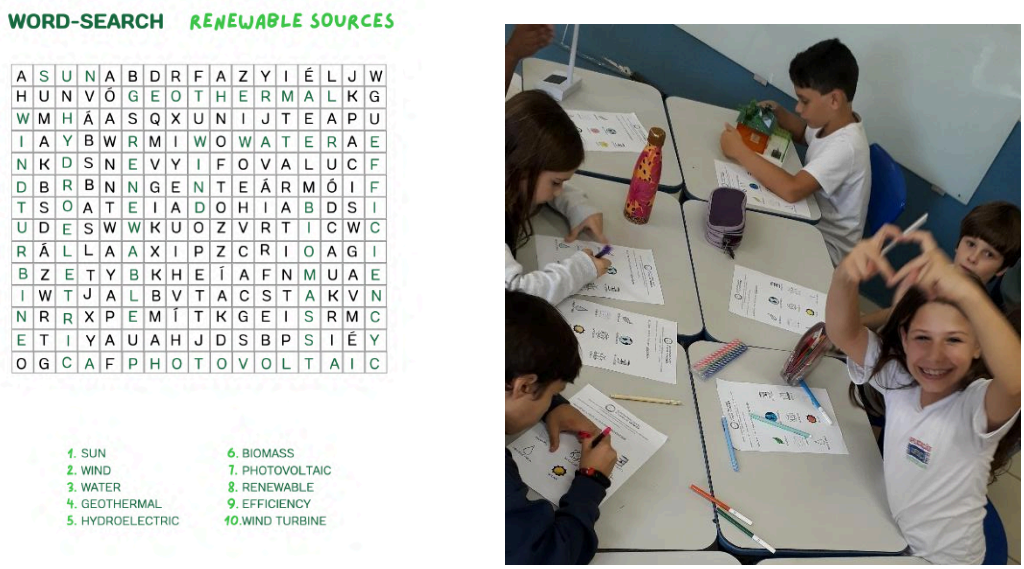


Fig. 2: Wind Energy Memory Game Icons and children playing the Memory Game (Author's Own)



Renewable sources word search (Fig 3.) and children in coloring activities (Fig. 4)

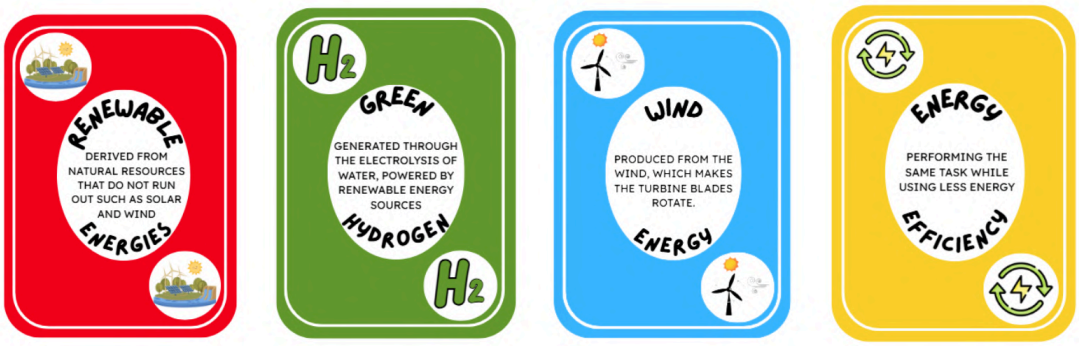


Fig. 5: Cards from the game Renewable Energy *Uno*, each containing a brief description of a specific energy source. (UFSC, 2025)

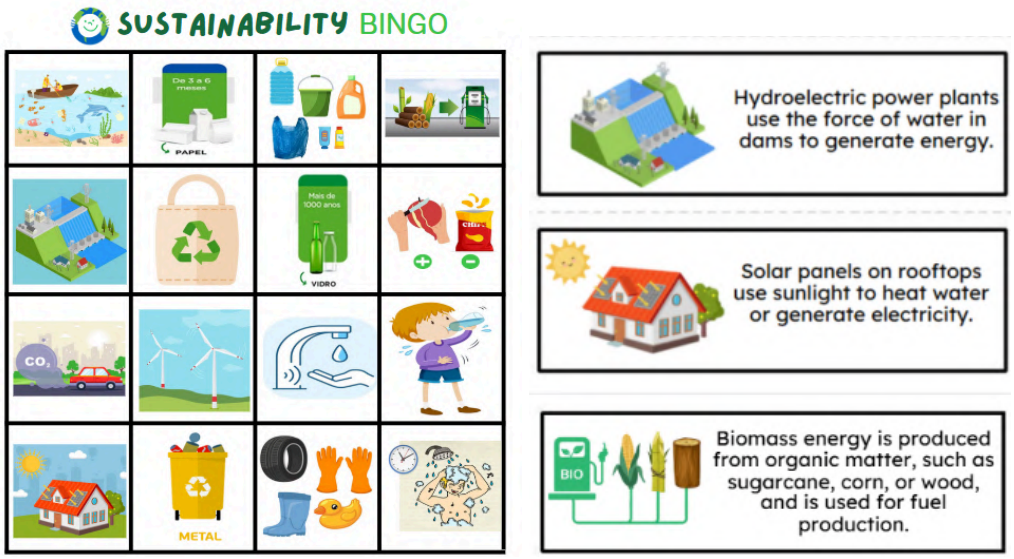


Fig. 6: Sustainability Bingo Icons

In addition to the games produced by the project, two educational resources are presented to students to demonstrate how solar energy generation works: a solar wind turbine and a solar house model (Figure 7). Both have an attached solar panel and when exposed to solar radiation, activate different mechanisms: on the wind turbine, the blades begin to spin, while in the solar house, internal lights turn on, a fan starts running and music plays. This activity enables students to visually and tangibly experience how solar energy can be applied in everyday contexts, reinforcing its potential as a clean and accessible source for diverse applications.

Fig. 7: Children testing the solar wind turbine model and the solar house model (Author's Own)

The lessons and workshops were conducted in four different schools in Florianópolis, southern Brazil, with students from 2nd to 6th grades. The content was previously coordinated with the teachers. In addition to the theoretical presentation, the practical component divided students into three groups, with the classroom organized into three workstations, each offering different games or activities. After 10 to 15 minutes, the groups rotated, ensuring that all students participated in each station. The activities generated strong engagement, consolidating learning in an interactive and participatory way while connecting concepts to everyday life. As Tilbury (2011) emphasizes, meaningful pedagogical practices must combine theory with practical action, particularly in the early stages of education.

Following the activities, teachers proposed learning records to consolidate knowledge and provide feedback on children's progress.

In addition to the activities with children, the project also includes teacher training, identified in literature as a key factor for advancing energy education (and education in general). Training sessions are delivered both in-person and online, ensuring that sustainability is integrated and maintained in classrooms. To broaden access, the project provides video lessons through its YouTube channel (*Educação para Sustentabilidade*,

2025).

The project also participates in fairs and outdoor events, offering activities like those used in schools, but involving families and the wider community (Figure 8). This reinforces the axis of awareness and public engagement. Community education and public awareness are highlighted as essential for fostering active citizenship.

Fig. 8: Project participation in the event *CineClube Trilhas de Criança* (author´s own).

The need for more projects of this kind is evident. Above all, however, it is essential that such content be reinforced within school curricula. Interest and curiosity about the topic were evident even in lower grades, indicating that the approach could be emphasized earlier than the 8th grade.

The results suggest that introducing the theme of renewable energy in elementary education through playful and participatory methodologies not only fosters children's immediate engagement but also supports the development of values and habits that may persist into adulthood. This approach highlights the role of schools as spaces for social transformation and demonstrates the potential for local initiatives to become references for national educational policies.

Another relevant point is the multiplying effect of this learning process. By bringing sustainability concepts into their homes, children become agents of change capable of raising awareness among families and communities. In this way, the project's impact extends beyond the classroom, strengthening collective awareness around the energy transition.

Despite the positive results, some challenges remain. The project's reach is still limited to schools in Florianópolis, underscoring the need for institutional support and public policies to enable expansion. Moreover, there is a lack of tools to assess the long-term impacts on the behavior of students and their families. Another challenge concerns the financial and institutional sustainability of university extension projects, which often depend on temporary funding calls and sporadic partnerships.

Teacher training also deserves attention: without adequately trained educators and access to high-quality materials, the subject risks remaining peripheral in school curricula. In this regard, the project has made progress by offering training, but a continuous effort is recommended to integrate renewable energy content transversally across disciplines already included in the BNCC, such as Science, Geography, Mathematics, and Arts.

Although the project demonstrated significant local impact, its scope is still limited to a specific region in southern Brazil, which raises questions about scalability and replicability in different socio-cultural and educational contexts. International literature shows that initiatives in Europe, North America, and Asia face similar barriers, such as lack of teacher training, limited curricular integration, and insufficient institutional support (Chen et al., 2023; Kandpal and Broman, 2014). This indicates that the challenges encountered in Florianópolis are not unique but rather part of a global trend in renewable energy education. Strengthening comparative analyses and fostering international cooperation could provide valuable insights into overcoming these barriers. For instance, exchange of pedagogical materials, teacher training programs, and cross-cultural research could enhance the transferability of successful strategies. In this sense, the project

contributes not only as a local practice but also as a potential model to inspire similar educational interventions in other regions facing the urgent need to prepare younger generations for the energy transition.

Since its inception in October 2023, the project has already reached 629 elementary school students from four schools in Florianópolis, southern Brazil, provided training to 43 teachers, and participated in seven events.

5. Conclusion

Addressing renewable energy education with younger audiences is not only relevant but also essential for fostering habits and values that will stay with them throughout their lives. The educational strategies developed in a playful, interdisciplinary, and accessible manner by the project Sustainability is a Child's Matter seeks to promote children's engagement with the principles of renewable energy, encouraging and stimulating conscious practices and a leading role in the energy transition and the challenges of the climate crisis.

Strengthening renewable energy education from early childhood is essential to prepare a new generation that is more critical and aware of the challenges posed by the climate crisis. The project analyzed demonstrates that interactive and accessible pedagogical strategies are effective in introducing children to complex concepts, fostering responsible attitudes, and promoting youth engagement in the sustainability debate.

For the future, it is recommended to expand partnerships with energy sector companies and public institutions, revise curricula, intensify teacher training, and develop longitudinal assessment tools to monitor the consolidation of learning outcomes.

Moreover, such initiatives should be encouraged, as they contribute to energy transition and align with the United Nations Sustainable Development Goals (SDGs) of the 2030 Agenda, particularly SDG 4 (Quality Education), by promoting meaningful and contextualized learning; SDG 7 (Affordable and Clean Energy), by encouraging knowledge about renewable sources and their transformative potential; and SDG 13 (Climate Action), by fostering attitudes that contribute to mitigating environmental impacts.

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