

CLIMATE EDUCATION IN BRAZIL: LESSONS AND PERSPECTIVES FROM A GLOBAL SOUTH COUNTRY

EDUCAÇÃO CLIMÁTICA NO BRASIL: LIÇÕES E PERSPECTIVAS DE UM PAÍS DO SUL GLOBAL

EDUCACIÓN CLIMÁTICA EN BRASIL: LECCIONES Y PERSPECTIVAS DESDE UN PAÍS DEL SUR GLOBAL

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ABSTRACT

The climate crisis poses an unprecedented challenge that requires systemic responses grounded in equity, resilience, and sustainability. Among these responses, education has been increasingly recognized as a strategic driver of long-term transformation. This article critically examines the integration of Climate Education into Brazil's formal education system, identifying key gaps in national curricular policy and drawing comparative insights from international experiences. Through a qualitative content analysis of academic literature, policy documents, and curriculum frameworks, including Brazil's National Common Curricular Base (BNCC), the study reveals that references to climate change remain superficial, fragmented, and inconsistently distributed across disciplines. By contrast, countries such as Italy, Scotland, and the U.S. state of New Jersey have adopted more comprehensive, interdisciplinary approaches to embedding climate topics across grade levels. Grounded in theoretical frameworks by Eisner and McNeil, the article evaluates the structural, cultural, and political dimensions of curriculum development, arguing for urgent reforms in teacher training, pedagogical resources, and policy alignment. The findings support the need for a context-sensitive, justice-oriented approach to Climate Education, one that promotes critical thinking, civic engagement, and behavioral change. As Brazil prepares to host COP 30, mainstreaming Climate Education is not only an ethical imperative but also a strategic pathway to empower future generations and strengthen democratic participation in climate governance.

Keywords: Climate Education. Climate Action. School Curriculum. Formal Education.

RESUMO

A crise climática representa um desafio sem precedentes que exige respostas sistêmicas baseadas em equidade, resiliência e sustentabilidade. Entre essas respostas, a educação tem sido cada vez mais reconhecida como um motor estratégico de transformação de longo prazo. Este artigo examina criticamente a integração da Educação Climática ao sistema educacional formal brasileiro, identificando lacunas importantes na política curricular nacional e extraindo insights comparativos de experiências internacionais. Por meio de uma análise qualitativa de conteúdo da literatura acadêmica, documentos de políticas públicas e estruturas curriculares, incluindo a Base Nacional Comum Curricular (BNCC) do Brasil, o

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estudo revela que as referências às mudanças climáticas permanecem superficiais, fragmentadas e distribuídas de forma inconsistente entre as disciplinas. Em contraste, países como Itália, Escócia e o estado americano de Nova Jersey adotaram abordagens mais abrangentes e interdisciplinares para incorporar tópicos climáticos em todos os níveis de ensino. Fundamentado nos referenciais teóricos de Eisner e McNeil, o artigo avalia as dimensões estrutural, cultural e política do desenvolvimento curricular, defendendo reformas urgentes na formação de professores, nos recursos pedagógicos e no alinhamento de políticas. Os resultados reforçam a necessidade de uma abordagem contextualizada e voltada para a justiça na Educação Climática, que promova o pensamento crítico, o engajamento cívico e a mudança comportamental. À medida que o Brasil se prepara para sediar a COP 30, a integração da Educação Climática não é apenas um imperativo ético, mas também um caminho estratégico para empoderar as gerações futuras e fortalecer a participação democrática na governança climática.

Palavras-chave: Educação Climática. Ação Climática. Currículo Escolar. Educação Formal.

RESUMEN

La crisis climática plantea un desafío sin precedentes que requiere respuestas sistémicas basadas en la equidad, la resiliencia y la sostenibilidad. Entre estas respuestas, la educación se ha reconocido cada vez más como un motor estratégico de transformación a largo plazo. Este artículo examina críticamente la integración de la Educación Climática en el sistema educativo formal brasileño, identificando brechas clave en la política curricular nacional y extrayendo perspectivas comparativas de experiencias internacionales. Mediante un análisis de contenido cualitativo de literatura académica, documentos de política y marcos curriculares, incluyendo la Base Curricular Nacional Común (BNCC) de Brasil, el estudio revela que las referencias al cambio climático siguen siendo superficiales, fragmentadas y distribuidas de forma inconsistente entre disciplinas. En contraste, países como Italia, Escocia y el estado estadounidense de Nueva Jersey han adoptado enfoques más integrales e interdisciplinarios para integrar temas climáticos en todos los niveles educativos. Con base en los marcos teóricos de Eisner y McNeil, el artículo evalúa las dimensiones estructurales, culturales y políticas del desarrollo curricular, abogando por reformas urgentes en la formación docente, los recursos pedagógicos y la alineación de políticas. Los hallazgos respaldan la necesidad de un enfoque de la Educación Climática que sea contextualizado y orientado a la justicia, que promueva el pensamiento crítico, la participación cívica y el cambio de comportamiento. Mientras Brasil se prepara para ser sede de la COP 30, la integración de la Educación Climática no solo es un imperativo ético, sino también una vía estratégica para empoderar a las generaciones futuras y fortalecer la participación democrática en la gobernanza climática.

Palabras clave: Educación Climática. Acción Climática. Currículo Escolar. Educación Formal.

1 INTRODUCTION

The climate crisis represents one of the greatest challenges of our time, demanding urgent and structural responses to mitigate its impacts. Among global strategies to address this emergency, education stands out as an essential element in shaping critical and engaged citizens capable of understanding the complexity of climate change and acting consciously. However, the transformative potential of education to drive societal change and accelerate the transition toward sustainable models remains underestimated and underutilized in public policies (KWAUK et al., 2021).

Climate Education is embedded within the broader framework of UNESCO's Education for Sustainable Development, which reinforces the need to prepare individuals and communities to respond to global environmental challenges. In 2014, UNESCO launched the Global Action Programme to strengthen and highlight Climate Education as a key component of the international response to the climate crisis (UNESCO, 2013). Similarly, the United Nations Sustainable Development Goals (SDGs), particularly SDG 13 ("Climate Action") and SDG 4 ("Quality Education") reaffirm the central role of education in building resilient and sustainable societies (O'NEILL et al., 2020). The success of these initiatives, however, depends not only on political commitments and governmental strategies but also on the dissemination of a more accessible and comprehensive concept of Climate Education.

The term "Climate Education" has gained relevance in both academic and political arenas as an approach that integrates climate issues into the broader environmental education spectrum. This integration prevents fragmented understanding and promotes a more holistic and interdisciplinary perspective on climate change in the classroom. This conception has been adopted by institutions such as the Brazilian Forum on Climate Change (FÓRUM BRASILEIRO DE MUDANÇA CLIMÁTICA, 2024) and the Brazilian Environmental Education Fund (FUNDO BRASILEIRO DE EDUCAÇÃO AMBIENTAL, 2024), which recognize the need to combine environmental and climate dimensions within a unified educational framework.

Although Climate Education is still under theoretical consolidation, its relevance lies in strengthening climate literacy and encouraging both mitigation and adaptation strategies (SILVA; BORBA, 2016). The Intergovernmental Panel on Climate Change (2017) emphasizes that Climate Education should address both how human activities impact the climate and the consequences of these transformations on societies and ecosystems. However, the complexity of climate systems and the lack of direct connections between curricular content

and students' everyday lives often hinder engagement and social mobilization for climate action (HESS; MAKI, 2019; OJALA, 2019).

The need for a more inclusive and accessible climate curriculum is also highlighted by the Brazilian Coalition for Climate Education (2023), which defines Climate Education as “an educational process to promote the necessary knowledge about the causes and effects of climate change, encouraging active participation in collective actions aimed at social transformation and the implementation of practices that ensure resilience and climate justice.” Thus, education should go beyond the transmission of scientific concepts to foster a culture of environmental responsibility, equipping individuals to make informed and sustainable decisions.

The United Nations recognizes that, in addition to emission reduction policies and governmental strategies, democratizing climate knowledge is essential to raise public awareness and engagement. In this sense, including climate science in school curricula becomes a strategic tool to ensure that society can understand and respond effectively to environmental challenges (UNESCO, 2017).

Despite its transformative potential, Climate Education still does not play a central role in public policies and school curricula in many countries, including Brazil. Often, the subject is approached superficially or as an extracurricular topic, which hinders the development of critical and proactive thinking among students. Furthermore, the unequal access to quality education exacerbates this scenario, as the most vulnerable communities, those most affected by climate change are often the least exposed to adequate education on the topic (OTTO et al., 2020).

To fulfill its transformative role, Climate Education must be structurally and interdisciplinarily integrated into school curricula. This requires teacher training, the development of updated teaching materials, and the promotion of methodologies that encourage student participation. Education should not be seen only as a long-term response to the climate crisis but also as a key driver of immediate behavioral and mindset changes (O'NEILL; SMITH, 2021). Therefore, this article aims to analyze the relevance of Climate Education as a strategic pillar to mobilize society toward sustainable behaviors and to effectively address the current climate emergency.

2 METHODOLOGY

This study adopts a qualitative and exploratory research approach to enable a deeper understanding of the phenomenon and to identify emerging perspectives (Creswell, 2014). The research focused on analyzing peer-reviewed articles, institutional reports, and national and international education policy documents, with particular attention to sources from recognized institutions such as UNESCO, UNFCCC, IPCC, OECD, and Brazil's National Common Curricular Base (BNCC).

Source selection was conducted through systematic searches in academic databases, including SciELO, Google Scholar, Web of Science, and ScienceDirect. Priority was given to publications from the last ten years to ensure the relevance and contemporaneity of the information. The documents were analyzed using thematic content analysis to identify patterns, gaps, and trends regarding the integration of Climate Education into school curricula.

This methodological framework allowed for a comprehensive examination of how Climate Education is articulated within formal education systems, both in Brazil and in selected international case studies. The combination of policy analysis and academic literature provided a robust foundation for evaluating current practices and proposing recommendations for curriculum reform and policy innovation in Climate Education.

3 HISTORICAL DEVELOPMENTS OF CLIMATE SCIENCE

Recent WMO data indicate that 2024 is set to be the warmest year on record. Since the 19th century, climate science has evolved through a series of discoveries that have progressively deepened our understanding of the interactions between human activity and the Earth's systems. Between 1800 and 1870, atmospheric CO₂ concentrations hovered around 290 ppm, and the global average temperature was approximately 13.6°C. These values began to rise significantly with the Industrial Revolution and the resulting increase in greenhouse gas emissions (IPCC, 2013). According to Weart (2003), early scientists such as Fourier and Tyndall were pioneers in recognizing the role of atmospheric gases in regulating Earth's temperature, an idea later expanded by Arrhenius and Chamberlin, who laid the foundations for the concept of anthropogenic global warming.

The 20th century was marked by rapid industrial and technological development, which further intensified environmental impacts. Temperature records and atmospheric gas concentrations continued to rise. Researchers such as Callendar and Revelle contributed to

the understanding of Earth's capacity to absorb CO₂ and the feedback mechanisms that could accelerate climate change (Weart, 2003). The growing awareness of risks, including polar ice sheet collapse and rising global temperatures helped galvanize the environmental movement, culminating in milestones such as the first Earth Day in 1970 (Rome, 2013).

In the final decades of the 20th century and into the 21st, climate science became a central element of global policy agendas. This period saw the creation of the Intergovernmental Panel on Climate Change (IPCC) and the ratification of key international agreements such as the Montreal Protocol and the Paris Agreement. These developments reflect an increasing recognition of the urgent need to reduce greenhouse gas emissions and to develop adaptation strategies in the face of irreversible climate impacts.

Recent reports underscore that temperatures continue to rise at alarming rates. According to the World Meteorological Organization (2024), the year 2024 is on track to be the hottest on record since global temperature monitoring began. This scenario highlights the growing urgency of limiting global warming and reinforces the pivotal role of climate science in shaping effective public policies. It also demonstrates the importance of raising awareness about the deep interconnections between human activities and the planet's climate system.

As climate science has advanced, the importance of Climate Education in engaging society and promoting sustainability has become increasingly evident. Integrating climate literacy into formal education is fundamental to equipping current and future generations with the knowledge and skills needed to understand historical and contemporary climate data. This, in turn, fosters a proactive and informed global society capable of contributing meaningfully to climate change mitigation and adaptation.

4 EDUCATION: THE OVERLOOKED PILLAR IN THE FIGHT AGAINST THE CLIMATE CRISIS

As the climate crisis accelerates at an alarming pace and demands urgent and coordinated responses, much of the global focus remains on emergency policies and technological innovation. Meanwhile, education continues to be underestimated as a long-term and systemic solution capable of fostering enduring social transformation. The role of schools in shaping environmental awareness and preparing future citizens to respond to complex climate challenges is often relegated to the background as if the climate crisis could be addressed solely through isolated technical actions (UNESCO, 2017).

Yet it is within classrooms that the foundations of a more climate-conscious society are built, one that can comprehend the multidimensional nature of the crisis and act toward sustainable solutions. Neglecting this dimension perpetuates a cycle in which environmentally harmful practices are reproduced generation after generation. Teaching about climate change is not merely a matter of delivering scientific facts; it is about fostering new mindsets that understand the consequences of individual and collective choices (UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, 2021). It requires nurturing values such as environmental responsibility, biodiversity conservation, and the recognition of the interdependence between humans and nature.

In Brazil, the marginalization of education in climate discourse reflects a broader structural failure. The limited and fragmented incorporation of Climate Education into public policy demonstrates a disconnect between environmental urgency and educational agendas. In many cases, climate topics are treated as secondary, restricted to extracurricular projects or superficial mentions in textbooks (QUINTANA & KITZMANN, 2020). This shallow approach undermines students' ability to grasp the full scope of the crisis and hinders the development of critical thinking skills necessary for informed action.

This situation is further exacerbated by widespread inequalities in access to quality education. While some private institutions have begun integrating climate themes into their curricula, most public schools lack the infrastructure and teacher training required for consistent, in-depth coverage. As a result, the communities most vulnerable to the impacts of climate change are often those with the least access to Climate Education (KWAUK et al., 2021).

There is no doubt that emergency mitigation and adaptation measures are crucial. However, without a parallel cultural shift, these actions will remain insufficient. Education holds the power to drive this transformation by equipping the next generation not only to cope with the crisis but also to reimagine development models that are fairer and more sustainable (OECD, 2020). Schools must cease to be spaces where the future is discussed abstractly and instead, become places where the future is actively shaped.

For this to occur, Climate Education must be prioritized in public policies and recognized as a core element in the fight against climate change. This requires investments in teacher professional development, the creation of interdisciplinary teaching materials, and the implementation of pedagogical strategies that empower students to take action. As Leff (2002) and Guimarães (2007) argue, rethinking the human-nature relationship is fundamental

to achieving sustainability. Incorporating Climate Education into school curricula is therefore an essential step toward aligning student formation with the realities of the climate crisis. The curriculum itself must become a strategic tool that turns knowledge into action, transforming learning into an ongoing meaningful experience that fosters environmental and civic responsibility.

5 CURRICULUM DEVELOPMENT AND CLIMATE EDUCATION

In critically evaluating Climate Education as an essential element to guide societies toward sustainable behavior and effective responses to the current climate emergency, it is vital to consider how national curricula address climate change in formal education.

The theoretical frameworks proposed by Eisner (1994) and McNeil (2006) offer robust models for analyzing how curricula can integrate or fail to integrate complex societal issues like climate change. Eisner categorizes curricula into four types: explicit, implicit, null, and extracurricular (Table 1). These categories help identify not only what is taught in schools but also what is omitted or informally transmitted through educational practices.

Table 1

Categories of school curricula

Type of Curriculum	Description
Explicit Curriculum	Refers to the formal knowledge, skills, and competencies that schools are mandated to teach, as defined by national or regional education standards.
Implicit Curriculum	Comprises the values and behaviors indirectly conveyed through school cultures and everyday practices, such as energy conservation campaigns, waste separation, or school gardens.
Null Curriculum	Refers to content that is deliberately excluded from the curriculum, often due to political tensions, lack of consensus, or insufficient teacher training. Topics such as climate emergency, environmental justice, or industry-related impacts may be neglected, depriving students of critical understanding.

Extracurricular Curriculum	Includes complementary activities outside formal instruction that support environmental awareness, such as reforestation projects, science fairs, public lectures, or local climate action initiatives.
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Source: (Adapted from Eisner, 1994).

Understanding these categories is essential to identifying both gaps and opportunities for implementing Climate Education in formal schooling. While explicit curricula provide the structured foundation for instruction, the implicit, null, and extracurricular dimensions offer insights into how environmental knowledge and values are (or are not) reinforced through institutional culture. A balanced approach across these levels can create a more comprehensive educational environment, where formal instruction and lived experience mutually reinforce climate-conscious learning.

McNeil (2006) expands on this analysis by proposing five types of curricular change that education systems can adopt to better integrate emerging issues like climate change. These include substitution, alteration, perturbation, restructuring, and shifts in value orientation (Table 2). Each reflects a different degree of institutional transformation and pedagogical commitment.

Table 2

Types of curriculum adjustments

Type of Adjustment	Description
Substitution	Implementation of entirely new curricula that replace existing ones, introducing a renewed framework for Climate Education.
Alteration	Targeted modifications to current curricula to incorporate or expand content related to climate change, often through new tools or interdisciplinary methods.
Perturbation	Structural changes within the school system that enable broader or more effective incorporation of climate-related topics.

Restructuring	Comprehensive reforms that integrate Climate Education holistically across all subject areas and grade levels.
Value Orientation Shift	Fundamental changes in educational values that promote a deeper understanding and critical engagement with climate issues, helping schools embrace sustainability as a cultural norm.

Source: (Adapted from McNeil, 2006).

These models highlight the strategic role of curriculum reform in advancing Climate Education. Substitution and restructuring offer deep systemic change, while alteration and perturbation represent incremental yet impactful steps. Shifts in value orientation, meanwhile, signal a more profound transformation, requiring schools to adopt new educational paradigms grounded in environmental ethics and civic responsibility.

Goodlad (1984) reinforces this perspective by framing the curriculum as a cultural product, shaped by the traditions, values, and histories of specific communities. In the context of the climate crisis, this cultural lens becomes especially relevant. It suggests that curricula are not merely instruments of instruction but also vehicles for cultural transformation. By embedding local environmental knowledge and sustainability practices into the curriculum, education systems can become agents of ecological and social change.

Thus, rethinking curriculum development is not only about what content is delivered, but how it reflects, shapes, and responds to the broader cultural and environmental contexts in which students live. A climate-responsive curriculum is key to cultivating a generation capable of both understanding and addressing the pressing challenges of our time.

6 GLOBAL OVERVIEWS OF CLIMATE EDUCATION

Several countries have developed national strategies to incorporate climate change education into their formal education systems. In 2016, a nationwide survey in the United States conducted by Plutzer et al. analyzed how climate change was addressed in science classrooms. While the majority of science teachers included climate-related content, many still repeated scientifically inaccurate claims. Approximately three-quarters of the teachers

dedicated at least one hour to discussing recent global warming, including 70% of elementary science teachers and 87% of high school biology teachers (PLUTZER et al., 2016).

In 2019, Italy became one of the first European countries to introduce mandatory climate change content across all school curricula. Through civic education classes focused on sustainability and environmental protection, Italian students began learning about climate change through a cross-disciplinary lens (HOROWITZ, 2019). In the United Kingdom, climate change is a mandatory component of the geography curriculum for students aged 11 to 14, with government-provided lesson plans covering topics such as meteorology, the human impact on climate, and sustainable development (QUALIFICATIONS AND CURRICULUM AUTHORITY, 2007).

In 2020, the state of New Jersey became the first U.S. state to mandate the inclusion of climate change education across all grade levels and subject areas. From kindergarten to high school, students are now exposed to climate topics not only in science, but also in subjects such as arts, world languages, social studies, and physical education. This approach is seen as crucial for preparing future generations to live and work in a climate-affected world (THE NEW YORK TIMES, 2023).

Other countries, such as Singapore and Scotland, have also adopted structured approaches to Climate Education. In Singapore, the secondary science curriculum includes a module titled “Science and the Environment,” which raises awareness of climate change and related environmental issues. Topics include anthropogenic causes of global warming, the role of greenhouse gases, and heat transfer mechanisms (GOH, 2023).

Scotland has developed the “Learning for Sustainability Action Plan 2023–2030,” aiming to embed sustainability at the core of the national education system by 2030. Through its “Curriculum for Excellence,” Scotland integrates principles of sustainable development and global citizenship throughout primary and secondary education. For example, the health and well-being component encourages risk management and emergency preparedness, while religious and moral education promotes reflection on the ethical implications of environmental choices. In science classes, students explore processes driving climate change and their impacts on living organisms. In social studies, they analyze climate threats and their consequences for critical regions and ways of life—fostering a multidisciplinary understanding of environmental challenges (SCOTTISH GOVERNMENT, 2023).

Despite these promising efforts, substantial gaps remain. A 2021 UNESCO global review of 100 national curricula, covering 129 documents, found that nearly half made no

mention of climate change. Among those that did, references were often superficial or inconsistent. Additionally, although nearly 95% of surveyed teachers believed in the importance of teaching about climate change and its impacts, many lacked proper training or resources to do so effectively (UNESCO, 2021).

International experiences demonstrate that integrating Climate Education into school curricula can play a vital role in preparing students for the environmental challenges of the 21st century. These examples reveal that Climate Education must become a global priority, not only to inform but also to mobilize youth and communities around sustainable solutions. For countries like Brazil, such initiatives provide valuable lessons and frameworks that can help strengthen national efforts to embed climate literacy into formal education in a consistent, interdisciplinary, and transformative manner.

7 CLIMATE CHANGE IN BRAZIL'S FORMAL EDUCATION SYSTEM

In Brazil, the inclusion of climate change in formal education remains limited, fragmented, and insufficiently integrated into national curriculum policies. According to a recent analysis by Spinelli (2023), the Brazilian National Common Curricular Base (BNCC) mentions the term “climate change” only three times, and exclusively within the field of Natural Sciences and Technologies at the upper secondary level. This narrow and superficial approach fails to reflect the urgency or complexity of the climate crisis.

Although the BNCC provides some flexibility to address climate change, particularly within Geography through thematic units such as “Nature, Environment, and Quality of Life,” the effective integration of such content depends largely on individual teacher initiative and interpretation. The absence of explicit guidance for incorporating climate change topics across different levels of education contributes to a disjointed and inconsistent learning experience (SATO, 2011).

This lack of clear curricular direction points to a broader structural challenge in Brazil's education system. Many teachers receive little to no training in environmental or climate-related issues, and the availability of updated, climate-relevant teaching materials remains scarce. These shortcomings limit the ability of schools to provide students with a comprehensive understanding of climate change and its socio-environmental implications (SILVA & SILVA, 2020).

Nonetheless, some promising initiatives have emerged in recent years. The *Escolas pelo Clima* (Schools for Climate) movement, created by the organization Reconecta, has

played an important role in promoting Climate Education within Brazilian schools. As of 2024, over 1,100 institutions across all regions of the country had signed on to the initiative, involving more than one million students and 70,000 educators, 72% of whom are part of the public school system. Participating schools commit to implementing at least one climate action project with students and offering one teacher training activity per academic year (RECONNECTTA, 2024).

At the public policy level, the Brazilian branch of The Climate Reality Project has contributed to the drafting and advocacy of bills aimed at mandating Climate Education across school curricula. The organization supports citizens in drafting legislative proposals and lobbying lawmakers to ensure their presentation and approval. As a result of these efforts, several proposals have already become law, such as Municipal Law No. 7,523 in Rio de Janeiro and State Law No. 18,955 in Ceará. These legal instruments represent important steps toward institutionalizing Climate Education and ensuring that climate change is addressed systematically within public education systems (THE CLIMATE REALITY PROJECT BRASIL, 2023).

For education to play an effective role in fostering climate-literate, engaged citizens, climate change must be addressed transversally across school curricula. Beyond the inclusion of content in specific subjects, this requires comprehensive efforts that include continuous teacher training, the development of pedagogical resources, and the adoption of participatory, student-centered teaching methodologies. Advancing this agenda will depend on the coordinated efforts of government agencies, schools, and civil society to position Climate Education not as a supplementary topic but as a foundational axis of contemporary education. Only through such systemic integration will it be possible to prepare a generation capable of addressing future climate challenges and contributing meaningfully to the construction of a more sustainable and equitable world (SILVA & SILVA, 2020).

8 INTEGRATING CLIMATE EDUCATION INTO FORMAL SCHOOLING: A PATHWAY TO SUSTAINABLE ACTION

As climate science continues to advance, highlighting both the historical contributions of early scientists and the pressing urgency for immediate action, it becomes increasingly clear that Climate Education must move beyond the mere transmission of information. The intersection of scientific knowledge and a curriculum capable of not only informing but also empowering students is a powerful tool for engaging society in sustainability. In this context,

the Brazilian curriculum faces the challenge of preparing citizens not only to understand the complexity of climate change but also to act responsibly and effectively in response to the climate emergency.

An educational model focused solely on economic and professional advancement without fostering an understanding of human–nature relationships is insufficient in addressing today's societal and environmental needs (SILVA & BORBA, 2016). Such an approach risks producing individuals disconnected from environmental awareness, thereby reducing the capacity of education to form critically engaged citizens. Interdisciplinary learning, rooted in environmental rationality, is essential to prevent the continued reproduction of development models centered on unsustainable consumption and disregard for the ecological consequences of human activity (LEFF, 2006).

Teaching climate-related issues in formal education must therefore be comprehensive and multidimensional. Students must be encouraged to understand that sustainability is not a set of isolated practices but a broad and interconnected framework that links economic, social, and environmental systems. Climate Education should equip students with the tools to critically analyze how human activities contribute to climate change, and how sustainable solutions can be implemented both through public policy and everyday practices (CAMBRIDGE UNIVERSITY PRESS, 2022).

Moreover, Climate Education must be contextualized within Brazil's unique socio-environmental realities, emphasizing the disproportionate impacts of climate change on vulnerable communities. This includes acknowledging social, economic, and health-related dimensions. A clear understanding of these dynamics is essential to foster ethical engagement and a sense of responsibility among students. The curriculum should encourage students to think critically and seek local solutions to global problems supporting sustainability not only through discourse but through tangible action (UNESCO, 2023).

A long-term study by Cordero et al. (2020) evaluated the impact of a university-level climate change course offered at San José State University (California, USA) on students' carbon emissions five years after course completion. The findings revealed a significant reduction in individual emissions, as students adopted more sustainable habits in waste management, energy use, transportation, and diet. On average, each student reduced their annual carbon footprint by 3.54 metric tons compared to the statewide average of 25.1 metric tons per person.

Beyond individual impacts, the study estimated the potential global effect of integrating Climate Education into high schools in middle- and high-income countries. If approximately 16% of high school students received formal education on climate change, global carbon emissions could be reduced by an estimated 19 gigatons by 2050. This underscores the transformative potential of education in driving behavioral change, rooted in a personal connection to climate solutions.

Additionally, Climate Education has significant economic implications. According to the Global Commission (2018) on the Economy and Climate, countries that adopt ambitious climate action between 2018 and 2030 could generate over 65 million low-carbon jobs and realize at least US\$26 trillion in net economic benefits by 2030.

Therefore, Climate Education is not only a critical tool for reducing emissions but also a promising pathway for inclusive economic development. Embedding climate topics into formal education is a strategic move for building long-term, community-driven sustainability. By equipping students with the knowledge and agency to respond to the climate crisis, education becomes a central force in creating a resilient and engaged society ready to face both present and future environmental challenges with responsibility and innovation.

9 FUTURE PERSPECTIVES AND RECOMMENDATIONS

The future of Climate Education must aim to prepare individuals not only with ecological awareness but also with practical skills to address the environmental challenges of the 21st century. Education systems must equip students with analytical tools and creative capacities to innovate for sustainability and to actively participate in climate adaptation and mitigation processes.

To this end, curriculum development should remain in continuous dialogue with climate science, translating complex data into accessible and actionable knowledge. The use of real-world case studies, interactive simulations, and educational games can enhance learning experiences, stimulate critical thinking, and promote problem-solving skills. In parallel, it is essential to foster international educational partnerships that enable the exchange of knowledge and practices across borders. Such global collaboration can enrich local understanding of diverse climate vulnerabilities and adaptive strategies, creating more contextually grounded and globally informed learning environments.

Furthermore, Climate Education must emphasize environmental ethics, encouraging students to reflect on the moral and social implications of their actions. A climate-responsive

curriculum should inspire long-term commitment to justice and intergenerational equity, fostering a culture of care, responsibility, and respect for the planet. Integrating counter-colonial epistemologies and indigenous knowledge systems can further deepen this engagement, enhancing the continuity between cultural heritage and sustainable futures.

The effectiveness of educational strategies must also be continually monitored and evaluated. This includes supporting research on climate pedagogy to ensure that Climate Education is grounded in evidence and responsive to evolving global conditions.

Importantly, Climate Education must go beyond individual engagement to develop political agency. It should empower students to participate in shaping climate policy, with a strong foundation in civic literacy and democratic processes. Schools must become spaces where students learn how policies are formed and how to influence them through informed voting, public consultations, and community-based advocacy.

To promote this, curricula should include policy case studies that examine the relationship between climate action and governance. Students should be trained in debate, critical media analysis, and advocacy techniques to effectively navigate and challenge climate misinformation and politically motivated narratives. A population that is scientifically literate and politically aware is essential to support evidence-based decision-making in climate governance.

Climate Education must also promote interdisciplinary collaboration, linking climate science with fields such as ethics, social sciences, and politics. This integrated approach can generate innovative solutions and foster the collective imagination needed to address the scale and complexity of the climate crisis.

A particularly valuable framework for advancing this agenda is provided by the Brazilian Coalition for Climate Education (2023), which outlines five key pillars for innovative curricula and effective pedagogy:

1. **Fostering Climate Resilience and Collective Empowerment:** Encourage community-level resilience and collective problem-solving in response to climate emergencies, promoting strategies of cooperation and regenerative innovation.
2. **Promoting Local and Context-Specific Climate Actions:** Support Climate Education initiatives that are tailored to the specific ecological, cultural, and social contexts of different territories, such as environmental preservation projects, waste management programs, and sustainable agriculture.
3. **Spreading Knowledge for Integrated Socio-Environmental Solutions:** Deepen understanding of climate emergencies and their socio-environmental implications while promoting public awareness of climate rights, loss and damage, and the need

for equitable solutions.

4. Transforming Behavior Toward a Positive Climate Culture: Foster paradigm shifts in values and attitudes by promoting environmental awareness, shared responsibility, and intergenerational justice—grounded in diverse knowledge systems and sustainable worldviews.

5. Understanding the Interconnection of Natural and Social Systems: Emphasize the interdependence between ecosystems and social structures, and promote the regeneration of natural resources in alignment with community well-being and ecological health.

These pillars highlight how Climate Education can be a dynamic and transformative force in building a culture of climate responsibility and justice. By integrating critical thinking, interdisciplinary learning, and active civic engagement, Climate Education can prepare a new generation of voters, advocates, and decision-makers capable of shaping a more equitable and sustainable future.

10 CONCLUSIONS

The climate crisis, one of the most pressing threats to humanity, demands responses that go beyond short-term technical solutions. When systematically integrated into formal education, Climate Education emerges as a powerful tool capable of shaping behaviors, influencing public policy, and reconfiguring social values toward sustainability. By equipping younger generations with critical and practical knowledge about climate change, education becomes an essential driver for building resilient societies that are better prepared for emerging environmental realities.

This study reinforces the need for educational approaches that transcend the mere transmission of scientific concepts, promoting learning processes that meaningfully connect students to both local and global dimensions of climate change. The development of critical, interdisciplinary thinking enables students to understand environmental impacts through multiple lenses: social, economic, and cultural. Without a structured educational framework that supports this transversal perspective, there remains a gap in forming citizens who are ready to actively engage in mitigation and adaptation efforts. International experiences demonstrate that implementing robust Climate Education programs can accelerate the transition toward more sustainable practices, fostering collective awareness that extends beyond the classroom. A curriculum that continuously and systematically addresses climate issues not only raises student awareness but also empowers them to influence their communities and networks promoting real transformative change.

Thus, the conversation around Climate Education must extend beyond academic discourse and be translated into effective public policy. Investment in teacher training, the production of locally relevant teaching materials, and the promotion of interdisciplinary methodologies are all essential to embedding Climate Education in formal schooling. Active participation by school leaders, educators, and students in shaping and implementing these initiatives will strengthen the connection between educational institutions, communities, and government actors, amplifying the long-term impact of Climate Education.

Ultimately, Climate Education must not be viewed as an isolated solution, but as a foundational strategy for transforming how society understands and responds to the climate crisis. By embedding this perspective into school curricula, we lay the groundwork for a more sustainable future, one in which education functions as both a driver of transformation and a safeguard for the planet.

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