

Communicating and Acting Critically in the Climate Change Context in a High School Science Education

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Abstract

This study aims to investigate how students mobilise scientific and socio-political knowledge about climate change in communicative actions directed at the public. It presents a teaching and learning proposal for high school science classes, focusing on critical communication and action in the context of climate change. Grounded in the Science-Technology-Society (STS) framework and Cultural-Historical Activity Theory (CHAT), the course aims to help students learn scientific knowledge about climate change while fostering critical agency to address socio-environmental challenges. The course, implemented with 37 high school students in São Paulo, Brazil, was structured into two phases: (i) one focused on foundational scientific concepts, historical context, and socio-political dimensions of climate change, and (ii) the other emphasising student-led interventions to communicate and act on the issue. Activities included lectures, group discussions, and projects such as creating social media campaigns, producing documentaries, and developing educational games. The data presented in this study comprise the didactic sequence of the course offered to students, along with the final reports they produced, which contain descriptions and analyses of the educational interventions they implemented. The findings highlight the importance of integrating scientific, political, and ethical dimensions in climate education, enabling students to understand the complexities of climate change and develop transformative agency.

Keywords: Climate change, science education, curriculum, educational proposal, Chat.

Introduction

We live through a historic turning point characterised by extreme weather events and projections that point to increasingly uncertain and conflict-laden future scenarios. Generations of students currently in school are confronted not only with the tangible impacts of climate change but also with apocalyptic narratives that shape their

perception of the present and their vision of the future. In this context, reflecting on the role of school science education and seeking meaningful ways of addressing the climate crisis within the educational environment becomes essential.

A range of international curriculum frameworks emphasises the need to critically engage with climate change in educational settings, acknowledging its threats to human livelihoods and its role in exacerbating socio-environmental vulnerabilities (UNESCO, 2016, 2017a, 2017b). In response, these frameworks advocate for developing skills and abilities that enable young people to adopt sustainable ways of living and act informed by scientific and technological knowledge (Bianchi et al., 2022). These documents propose that climate education should be grounded in dynamic, interdisciplinary, and transdisciplinary methodologies centred on action, problem-solving, and the development of systemic and critical thinking (UNESCO, 2017b;). It is also important to highlight attempts to promote entrepreneurship based on the values of education for sustainable development (Lindner, 2018; Strachan, 2018; Heasley et al., 2025).

Brazil has been directly impacted by extreme weather events, mainly due to increased rainfall extremes, which cause hydrometeorological disasters in a country of continental dimensions, with diverse regional characteristics of biomes and affected by socioeconomic inequality, culminating in factors that condition the impacts of extreme events in the country (Perez et al., 2020). The latest Brazilian curriculum reform advocates a structure that, based on different areas of knowledge, addresses social and work contexts, also taking into account the relationship between the local and the global, the interests of students, and the possibilities offered by educational systems with teaching-learning methodologies that should favour the active role of students (BRASIL, 2018a). It specifically considers that the presence of science and technology in global and local issues, such as climate change, has incorporated the concerns of many Brazilians. Therefore, science education should be seen not only as a tool capable of solving problems but also as an opening to new worldviews (Brasil, 2018b). These international e Brazilian guidelines represent important advances in recognising climate change as a central socio-environmental contradiction connected to issues such as poverty, natural disasters, economic crises, food security, energy use, biodiversity, and the formulation of public policies (Xiaomin & Auld, 2020). However, fundamental issues still have not been discussed, such as whether climate education should be the same for all social classes and nations despite the different responsibilities in generating the problem or if it is appropriate to focus on forming individual competencies to face a crisis caused by wealthy nations and economic actors with highly concentrated power, or if we should bet on technical solutions to mitigate CO₂ or on structural transformations in the modes of production and consumption.

Addressing these issues requires adopting a critical educational approach (Janney et al., 2024). We acknowledge that there are multiple ways to engage with the topic in basic education – ranging from transmitting information about the causes and consequences of climate change and promoting individual or collective sustainable actions to the critical analysis of the political-economic structures underpinning the crisis (Oberman & Martínez Sainz, 2021; Kranz et al., 2022). These approaches are not mutually exclusive. They can and should be integrated to reflect the issue's complexity and avoid naïve or reductive perspectives. One of the key challenges in advancing critical climate education in basic education is the difficulty teachers face in designing and implementing curricula that integrate up-to-date scientific knowledge, interdisciplinarity, and pedagogical approaches aligned with educational goals (Zezzo & Coltri, 2022). We need to move forward in defining the agency we aim to develop with

our students and deepen our understanding of the curricular structures that best align with this goal.

The question that guides our work is: how do students mobilise scientific and political-social knowledge about climate change in communicative actions aimed at the public? In this article, we aim to contribute to the ongoing debate by presenting and analysing a climate change course designed for high school students at a private school in São Paulo, Brazil. Grounded in a critical science education perspective, the course draws on the Science-Technology-Society (STS) framework and Cultural-Historical Activity Theory (CHAT), aiming to foster students' critical agency through communicative practices and transformative interventions.

Theoretical frameworks

Less STEM and more STS

The technicist paradigm that guided science education during the Cold War, especially in the United States, still strongly influences contemporary educational systems (Lopez & Mattos, 2024; Aikenhead, 2023). Currently represented by Science, Technology, Engineering, and Mathematics (STEM) proposals, this approach aims to train individuals to work technically in scientific and technological fields, thereby stimulating economic competitiveness through methodologies such as Problem-Based Learning and Teaching by Inquiry (Rodrigues, Camillo, & Mattos, 2023). However, this approach treats most social issues as merely technical problems, neglecting the ethical, political, and cultural dimensions of knowledge (Zeidler, 2016).

In contrast, the Science-Technology-Society (STS) movement, which emerged in the 1970s and 1980s, proposes a scientific education to form critical citizens capable of understanding the social and environmental impacts of scientific and technological development (Rodrigues; Camillo; De Mattos, 2023). This perspective seeks not only the instrumentalisation of students but also the construction of mediations between scientific knowledge and social problems, focusing on the contradictions that arise from capitalist modes of production, social inequality, and environmental conflicts (Strieder, 2012; Strieder, Bravo Torija, & Gil Quílez, 2017).

For Aikenhead (2005), the main objective of STS education is to educate students to understand the human dimensions of scientific practice and recognise its social, ethical, and political implications. Despite this, the STS movement suffered setbacks in the 1990s, with the rise of specialised and technicist approaches that began to be incorporated even in the early years of basic education (Fensham, 2022). Even so, given the severity of the climate crisis, the STS approach reemerges as a necessary alternative, mainly due to its potential to articulate scientific knowledge and citizen engagement.

The selection of topics from the STS perspective favours socially relevant issues that are scientifically grounded and have the potential to generate debate on controversial topics. This approach enables students to grasp the conceptual foundations of science and its implications for daily life, thereby broadening their understanding of contemporary social and environmental issues.

Agency, Future, and Transformation: CHAT Contributions

The STS approach, which foregrounds the interrelations among science, technology, and society, attains greater analytical depth when integrated with the Cultural-Historical Activity Theory (CHAT), particularly concerning the conceptualisation of agency. For CHAT, all human activity is culturally and historically mediated by instruments and signs, being directed to an object that materialises the

motive of the activity (Engeström, 2001). Contradictions serve as the dynamic driving force behind human activity. It is the tension arising from these contradictions that propel change and transformation, thereby shaping the process that Engeström (2001) describes as “expansive learning”. This learning occurs when subjects facing limits in their activities produce new ways of acting collectively, breaking with established patterns and producing the “untested feasible” in Freirean terms (Freire, 2005).

Within this framework, the concept of agency acquires a collective, historical, and transformative dimension. Stetsenko (2020) proposes that agency should not be viewed as an isolated attribute of individuals but rather as the result of active participation in socially significant activities. Against deterministic or functionalist views of human action, Stetsenko argues that we are all simultaneously products and producers of human activity.

From this perspective, Vianna and Stetsenko (2014) develop the concept of *Transformative Activist Positioning* (TAP), in which agency is related to a utopian dimension, understood not as an unattainable ideal but as an ethical horizon that guides the present practice. In this sense, education should create spaces for subjects to elaborate on conceptions of the future based on ethical and political assumptions, enabling them to act in a conscious, responsible, and transformative way.

This approach to climate education implies understanding students as historical and social subjects, with the potential to analyse the world beyond the most immediate evidence, usually based on individual actions. Instead, it means understanding that climate change occurs through the interaction of different hierarchical levels of human activity (IPCC, 2023). In this context, the agency is understood as producing conscious awareness, overcoming alienation, and strengthening a collective engagement aimed at socio-environmental justice. Thus, by articulating STS and CHAT, this educational proposal aims to conceptualise the climate crisis and form critical, conscious persons capable of communicating and acting politically in favour of structural changes in society.

In the following sections, we introduce our proposal, which was implemented with high school students to address the complex scientific and cultural issues related to climate change.

Methodology

The research is based on the Action Research model of study, in which a particular case of teaching and learning is studied and reflected along with the teacher who conducted the process (Lesh, 2014), more specifically in the teacher-centred action research, where practices were developed in dialogue with academic discussion (Laudonia et al., 2018). In this sense, this article presents the design and implementation of a high school course on climate change, followed by an analysis of the students’ resulting work, with particular emphasis on the development of their critical communicative agency.

Grounded in the principles of the Science-Technology-Society (STS) approach to science education and drawing on the contributions of Cultural-Historical Activity Theory (CHAT) to understanding critical agency, we designed a course that integrates the scientific, political, and economic dimensions of climate change. The course also sought opportunities for students to engage in communicative actions directed at concrete audiences.

The proposal was developed in the second semester of 2024 with 37 second-year high school students (aged 16–17) from a private school in São Paulo, Brazil. The first

author of this article is a teacher of this class and developed the course based on the contribution of his doctoral research. The Brazilian basic education system includes nine years of primary education and three years of high school; the course was designed specifically for this educational context. It comprised 44 instructional hours distributed over one academic term. This course structure is referred to as a “Curricular Unit” within a “Formative Itinerary”, a framework established in the latest Brazilian curriculum reform (BRASIL, 2018c). The primary data collected consisted of the course’s didactic sequence and the students’ final productions, compiled in the reports they submitted at the end of the course.

The course was organised into two main phases: one focused on theoretical climate literacy and the second on practices that more closely developed agency. The first phase, characterised by more centralised teaching practices, consisted of dialogic-lecture classes designed to problematise the object of study—climate change. This phase addressed key issues, including the historical development of climate knowledge (with its core concepts, authors, and institutions), the identification of responsible agents, perspectives from environmental movements, mitigation strategies, the sense of urgency, climate agreements, and principles of environmental justice.

In the second phase, students were invited to collaboratively design and implement interventionist projects to foster communication and critical engagement with climate change. These group projects began with selecting a relevant thematic focus, which was then explored through research and translated into communicative outputs such as social media campaigns, educational sessions for younger students, documentary films, and educational games.

The planning and systematisation of the course followed van den Akker’s (2010) curriculum components framework, which comprises ten key elements: (i) Justification, which explains why the proposed teaching and learning activities are necessary, important, and relevant; (ii) Aims and objectives, which describe the various aims that the teaching and learning activities aim to achieve; (iii) Content, which outlines the subject matter underpinning the activities, such as disciplinary knowledge, practices, attitudes, and competencies; (iv) Teaching and learning activities, which detail the methodologies that will engage both teachers and students in educational practice; (v) Role of the teacher, which defines the activities teachers must carry out in their practice; (vi) Materials and resources, which specify the physical artifacts to be used by teachers and students; (vii) Groupings, which outline the collaborative levels at which students should organise themselves; (viii) Location, which indicates where the educational activities should take place; (ix) Time, which specifies when and for how long the activities should occur; and (x) Assessment, which describes how the teaching and learning processes will be evaluated. The systematisation of these curricular elements helps us both in the organisation and planning lessons, as well as in the aspects that should be observed and analysed during the analytical stage.

In the “Didactic sequence” section, we describe the structure of the proposed course. In the “Results and discussion” section, we describe and analyse the students’ works produced during the second phase of the course. This description was based on reading and organising the final reports produced by the students. In this analysis, we aim to highlight the specific elements of these works that indicate the promotion of their agency, conceptualised from the CHAT perspective. In the last section of the paper, “Final Considerations”, we present the formative potential of the course for developing students’ agency concerning climate change in a proposal based on communicative

interventions on the subject. These conclusions are based on our theoretical framework, the proposed didactic sequence and the students' interventions.

Didactic Sequence

This section presents the teaching and learning activities implemented during the first stage of the course, which comprised 13 classes dedicated to establishing the foundational scientific concepts essential for understanding climate phenomena and the key historical, political, and economic dimensions of the climate crisis and its mitigation.

The instructional sequence began with *Class 1*, which focused on presenting the course and surveying students' prior conceptions about climate change. The students were invited to express their self-evaluation on the blackboard regarding knowledge of the causes, consequences, mitigation strategies, and international agreements, and to share their sense of urgency and emotional responses to the climate crisis.

Classes 2 and 3 introduced fundamental physicochemical concepts related to the greenhouse effect, along with the structure and function of the atmosphere. These were conducted as dialogical sessions, with students recording and organising content such as heat exchange processes, the role of greenhouse gases, and the importance of the atmosphere in sustaining life on Earth.

Classes 4 and 5 focused on the carbon economy, the Industrial Revolution, and its impacts on atmospheric composition. The students analysed historical data and the carbon cycle and were introduced to the early institutionalisation of the international climate debate.

Class 6 was dedicated to studying the Intergovernmental Panel on Climate Change (IPCC) reports, with a particular emphasis on the "Summary for Policymakers" from the 2023 report. The activity involved collective reading and synthesis of key topics, supported by students with good English proficiency. Both the document's contents and the data presentation's structure were explored, especially the confidence levels of the arguments.

Classes 7 and 8 addressed the political and economic contradictions embedded in climate agreements. The students reviewed data on historical CO₂ emissions and the rising global average temperature, engaging in a guided discussion about the complexities and challenges associated with mitigation efforts. The main environmental and climate agreements were presented and discussed, with a particular emphasis on the Earth Summit (ECO 92), the Kyoto Protocol, and the Paris Agreement.

Class 9 involved a written exam completed in pairs, with access to class notes, aimed at assessing the students' conceptual and factual understanding of the content covered up to that point.

Classes 10 and 11 focused on discussions about climate denialism, social inequalities, and adaptation strategies. The students analysed an interview with Bruno Latour, examined the intersections between politics, science, and communication, and were introduced to key concepts in environmental justice.

In *Class 12*, the students were engaged in collaborative feedback and peer correction of the exam. Each pair evaluated another group's responses based on pre-established criteria, followed by a collective review session to refine and adjust answers.

Finally, *Class 13* revisited the central concepts addressed throughout the course, focusing on deepening the discussions on climate justice and environmental racism. The session concluded with a discussion on the various strands of environmentalism and climate projections extending through the end of the 21st century.

This initial stage was crucial for establishing a shared repertoire of knowledge and laying the conceptual foundations that supported the next phase of the course: the design and implementation of student-led intervention projects, which are presented in the following section.

Student intervention projects

The second stage of the course focused on developing authorial interventions, aiming to engage students in critical communication about climate change. This phase began in Class 14 with the formation of working groups and extended through to Class 44, encompassing a total of 31 sessions dedicated to planning, implementation, analysis, and presentation of the interventions.

The students were invited to select a thematic focus related to the content previously explored in class and, from that starting point, to design a communicative action targeting a real audience. To support this process, a set of guiding questions was proposed to stimulate reflection and inform their choices: Which discussions resonate most with me? Who should be the central voice in the climate change debate? What do I appreciate—or find problematic—about how this topic is typically presented? What aspects of the current discourse on climate change do I believe need to change? What areas do I feel I lack knowledge but see as essential for understanding the issue? And finally, what do I already understand yet believe needs to be further deepened to grasp the complexity of the problem?

Different formats were suggested for this action, such as workshops with other classes, producing materials for social networks, creating videos, engaging in political mobilisation, communicating through mass media, developing games, hosting expositions, and staging artistic performances. The professor actively mediated the entire process, offering suggestions, assisting in defining thematic focuses, and guiding conceptual elaboration and refinement strategies. The stages of the intervention are in Table 1.

Table 1

The Organisation of Classes Focused on Student Intervention

Classes	Activity
14	Definition of groups (4-5 students) and themes; start of production of intervention projects.
15 to 18	Discussion of thematic cuts, definition of the type of intervention, and delivery of the preliminary project.
19 to 40	Research, development, and execution of interventions.
33	Intermediate anonymous self-assessment of the process.
41	Delivery of the intervention report and response to the self-assessment and final co-evaluation.
42 to 44	Final presentation of the interventions by the groups.

Eight distinct projects were developed, encompassing a variety of themes and formats. These interventions reflected the students' diverse interests and the multifaceted nature of the climate crisis. The projects addressed various topics, including climate denialism, environmentalist discourses, energy transition, environmental justice, climate anxiety, and environmental education for children. Various media and communication strategies were employed, including videos, exhibitions, social media platforms, dramatisations, and educational games.

Each group submitted a final report detailing the objectives of their intervention, the conceptual elaboration undertaken, the methodology employed, the implementation process, and the main outcomes observed. These reports provided the foundation for both the systematisation and evaluation of the interventions, constituting a substantial component of the students' final assessment.

Assessment

Assessment in the first phase consisted of a written test conducted in pairs, with students allowed to consult class materials as needed. In the second phase, the assessment included the delivery of the group intervention project, a final report describing the activity, as well as students' reflections, along with both self-evaluation and peer evaluation.

Results and Discussion: Description and Analysis of Students' Production

The first activity analysed centred on the theme of **climate denialism**, exploring its mechanisms and the harm it causes to efforts in confronting the climate crisis. The intervention was designed to engage eighth-grade students (aged 13–14) in discussions about how denialism obstructs the communication of climate projections. It aimed to clarify the reasons behind the scientific community's often cautious posture, frequently influenced by demands for immediate empirical validation, and to identify the main actors contributing to the denialist discourse.

"Among the various aspects that represent obstacles for us to deal with this problem, the one that interested our group the most was climate denialism, and for this reason, we chose to deepen our research on this topic in order to understand what the logic behind it was, and what its consequences were for the rest of the world in the fight against climate change." (Report, Group 1)

The activity required students to develop skills in evaluating information sources and critically assessing their credibility. It took place over a one-hour class and was organised into three phases: it began with a provocative question—"Should scientists speak openly about issues that affect us?"—followed by a student-led presentation summarising key findings from their research. The class concluded with a structured debate in which one group argued for limiting scientific communication on extreme weather forecasts while the other defended the broad dissemination of such information.

The objectives of the intervention on climate denialism were strongly oriented towards promoting the critical agency of eighth-grade students, based on problematising the social, political, and epistemological implications of science denial. The group's primary purpose was to "acquire a theoretical basis on climate denialism so that we could then disseminate what we had learned about its impact on science to the schoolchildren" (Report, Group 1), showing concern with the critical mediation of knowledge. The focus was not limited to transmitting information but rather to fostering a dialogue with younger colleagues about the consequences of denialism for the production and communication of scientific knowledge. Thus, the intervention aimed to "demonstrate to eighth graders that the fear of climate denialism is present in the daily life of the scientific community" (Report, Group 1), thereby stimulating reflection on the limitations of scientific communication in the face of disinformation.

Another explicit objective of the activity was to raise awareness about the dissemination of fake news and the role of political actors in worsening the climate crisis, aiming to cultivate a critical stance toward information sources. As stated by one

group in their final report: “to show that denialism and fake news can originate from various [sources], especially from politicians who play an important role in climate issues, to make them think about the importance of knowing where you are getting certain information from, as well as questioning its veracity” (Report, Group 1).

The results reported indicate that the objective of critically involving the target audience was achieved, as revealed in the following statements: “the students showed themselves to be very capable of arguing with what we had presented, even adding new arguments to their defences” and “the debates in the three classrooms were very well-founded, and the students really got involved with the topic” (Report, Group 1). The spontaneous demand for the activity to continue reinforces this diagnosis: “in one of the classrooms, they even asked us to ‘steal’ a bit of time from the next class so that they could continue with the debate” (Report, Group 1).

Finally, the group produced an ethical synthesis of the discussion, stating that “the commitment of scientists should not be to the deniers, but to fighting climate change and for the future of young people.” This signals the appropriation of a critical and committed stance towards the climate crisis, in line with the educational objectives of the pedagogical proposal.

The second activity, “**Vila pelo Clima**,”¹ aimed to amplify underrepresented environmental issues by creating an Instagram page featuring climate activism content. The initiative involved mapping urgent climate-related discussions within the school community and broader society, aiming to raise awareness about climate change—a topic still insufficiently addressed in the school curriculum. Additionally, the group explored various textual and visual communication strategies to enhance audience engagement.

“Our general objective was to reactivate ‘Vila pelo Clima’ to raise awareness among the school community about climate change and the environment... So we thought we’d reactivate the ‘Vila pelo Clima’ Instagram, which ultimately reaches all of humanity. Thinking, in particular, that Instagram is a social network that covers most of society...” (Report, Group 2).

The objectives of the “Vila pelo Clima” activity were centred on expanding the reach and circulation of informative and critical content about climate change on social networks, with special attention to the school community and users engaged in digital platforms. The group reports that by “reactivating Instagram, we aimed to reach the school community and, beyond that, people who are continuously following news on social networks” (Report, Group 2), showing a clear intention to exploit the communicative potential of the digital medium to promote climate awareness. The regular production of content for the feed and stories sought to consolidate an active and continuous presence of the environmental agenda in the daily lives of followers: “posting in the feed and stories with some frequency [...] helped us to move and reach an audience that already followed the account” (Report, Group 2).

From a quantitative perspective, the results show a notable increase in the visibility of the account: “last month (October), 5,400 people viewed our profile” (Report, Group 2), a substantial rise from the previous average of just 240 monthly views. This data led the group to reflect on the progress in expanding their reach despite the inherent challenges: “we believe that, although engagement is difficult, we have managed to reach a considerable number of people” (Report, Group 2). However, the

¹ In English is “Vila for the climate”, where “Vila” is the school’s name (Escola da Vila).

group also critically recognises the limits of the action, pointing out the difficulty of transforming views into effective interactions with the content: “despite the good viewing figures we obtained, engagement was very difficult” (Report, Group 2). The finding that “we got very few likes on the posts, showing that people probably just looked at the post and didn’t read the content we were trying to bring” (Report, Group 2) highlights a reflection on the obstacles faced in mobilising the digital public in a deeper and more participatory way.

Thus, the intervention’s objectives combined the quest to broaden the reach of climate communication in digital environments with the effort to develop engaging strategies to bring the public closer to environmental discussions. Recognising the limits and potential of this approach reveals an important training process aimed at building critical communication skills in contemporary contexts marked by the accelerated and fragmented circulation of information.

The third activity involved the analysis of the **different environmentalist discourses in the face of the climate crisis**, focusing on the various aspects of environmentalism and the influence of political and social ideologies on environmental actions. To this end, students conducted interviews with professionals working in fields related to climate issues to map diverse strategies for addressing the crisis. Interviews were held with a representative from *Mercado Livre*² and a collaborator from *Greenpeace*, during which the participants discussed the nature of their work, the extent to which climate agendas are integrated within their respective institutions, and the principal challenges encountered in advancing environmental initiatives.

“[...] environmentalism unfolds in different strands, reflecting a range of perspectives that influence the way individuals and collectives understand and approach the climate crisis. Thus, our objective, which motivated the development of our work, was to understand these different strands of environmentalist discourse and how the environment in which you are inserted interferes with your perspectives on this issue.” (Report, Group 3)

The activity culminated in the creation of a poster that synthesised various ideological positions—namely, “critical left,” “denialism,” “NGO conservationism,” and “green capitalism.” The poster was illustrated using insights from the interview responses, emphasising the latter two categories.

The activity aimed to critically examine the diverse discourses within environmentalism and foster a more nuanced and integrated understanding of the responses to the climate crisis. The group sought to highlight that while different strands of environmentalism offer distinct approaches to addressing ecological challenges, these perspectives are not always aligned or mutually reinforcing. On the contrary, “the contradictions between them reinforce the need for integrated actions that consider both social justice and ecological constraints” (Report, Group 2), revealing a concern about overcoming partial or fragmented visions of sustainability. With this, the group proposed an articulation between environmental justice and planetary limits, pointing to the importance of solutions that inseparably combine social and ecological aspects. In addition, the students emphasised the importance of expanding the debate on who bears responsibility for the necessary transformations, underscoring the role of institutional and collective action over approaches that focus solely on individual behaviour: “we highlight the role of institutions and individuals in promoting a broad

² One of the largest Latin American e-commerce companies.

awareness that goes beyond individual actions, encompassing structural changes in public policies and the market" (Report, Group 2). In this way, the purpose of the activity was not only to map the different environmentalist discourses but also to promote a critical reading among the interlocutors of the ideological disputes surrounding the fight against the climate crisis. By combining scientific knowledge, political reflections, and discursive analysis, the group demonstrated its commitment to investigating structural transformations, aligning with the pedagogical proposal's educational objectives.

The fourth activity took the form of an **artistic performance**, titled "*Uncertainty is the Only Certainty*," which aimed to explore the theme of climate change through artistic expression, deliberately avoiding apocalyptic or fictionalised representations.

"Our proposal is related to the fact that the arts usually find it difficult to deal with climate change in a way that isn't science fiction, in other words, it's always portrayed in apocalyptic scenarios as if it were the equivalent of an alien invasion or a zombie apocalypse." (Report, Group 4)

Drawing inspiration from Amitav Ghosh's (2016) *The Great Derangement*, the intervention centred on producing a chronicle. This short story portrays the everyday experiences of São Paulo residents in the context of climate change, adopting a non-alarmist and reflective narrative tone. The resulting text was performed as part of a school literary event.

The primary objective of the activity was to explore alternative representations of climate change through artistic expression, intentionally distancing itself from both alarmist and denialist narratives. The proposal, which focused on creating and publicly reading a chronicle or short story, aimed to foster nuanced and everyday engagement with climate issues, particularly within the urban context of São Paulo.

According to the students, "we wrote a chronicle/story to deal with climate change in the daily lives of São Paulo citizens in a non-alarmist way that brings people closer to the cause" (Report, Group 4), making it clear that the aim was to mobilise the public through a narrative approach that avoided the extremes of catastrophism and denial. The performance held during the poetry and sound festival in the school on November 23, 2024, was considered a key moment in achieving this goal: "more important than the text itself [...] we were able to bring people closer to the cause effectively" (Report, Group 4). The group also demonstrated an explicit intention to challenge the hegemonic ways in which the climate crisis is represented in the artistic field, highlighting the potential of art as a means of re-signification and engagement: "we were able to subvert the relationships established between the arts and climate change [...] by proving that we can see them and portray them differently in the artistic world" (Report, Group 4). This statement reveals a critical stance towards the limitations of conventional climate imagery and a creative effort to broaden the possibilities for awareness and reflection.

Thus, the intervention articulated aesthetic production, discursive criticism, and socio-political engagement, promoting a communicative agency that challenges the dichotomies between scientific reason and artistic expression. By proposing a narrative that incorporates climate change into everyday life without losing its ethical and transformative horizon, the group fulfilled its objectives in an authorial and innovative way, aligning with the interdisciplinary and emancipatory perspective of the pedagogical proposal.

In the fifth activity, the **possibilities of clean energy in Brazil** were investigated to study sustainable energy sources, evaluating their productivity, socio-environmental impacts, and the limits of the so-called energy transition since even sources considered

“clean” can generate greenhouse gas emissions. The intervention included the construction of comparative tables on different plants, considering aspects such as occupied area, energy produced, costs, emissions, pros, and cons. Models were also created and later exhibited in the school library.

“With the world witnessing increasingly intense and damaging global warming, there has been an increase in mitigation plans and strategies, the main one being the creation of more sustainable and ‘clean’ means of production. Thus, our main objective was to study sustainable energy proposals in Brazil, analysing various aspects involved not only in producing this energy, but also in installing the plant aimed at it.” (Report, Group 5)

The main objective of the intervention was to promote a critical analysis of the possibilities and limitations of the so-called “clean energy” in Brazil, demystifying the idea that such sources are definitive solutions and free of socio-environmental impacts. The group sought to deepen the debate on the energy transition, combining technical data with political and environmental reflections.

From the outset, the students demonstrated their awareness of the complexity of the issue: “it became clear that we needed to address more sustainable energy options without creating an illusion that these are immediate and definitive solutions to the problem of climate change” (Report, Group 5). To achieve this, they invested in creating models accompanied by informative data, aiming to communicate the various variables involved in energy production in an accessible and visual way. The decision to incorporate the cost of energy production and the “cost of building the plants, which also has a high climate impact” (Report, Group 5) demonstrates the group’s effort to provide a more comprehensive and grounded approach.

At the conclusion of their work, the students summarised their position clearly: “Clean energy proposals in Brazil are an effective alternative for combating climate change, but the energy transition alone will not significantly reduce socio-environmental impacts” (Report, Group 5). This statement highlights an important distinction between the contribution of renewable energies and the necessity for broader structural transformations, such as “the construction of railroads, public transportation, the structural revision of the mode of production” (Report, Group 5). In addition, the group emphasised the importance of deconstructing the perception that clean energy is totally sustainable, pointing to the socio-environmental impacts associated with its implementation, such as deforestation, gas emissions during construction, and pollution of water bodies.

Thus, the activity’s objectives centred on building critical knowledge about the energy transition, going beyond the technocratic optimism often associated with renewable sources. By mobilising data, visual resources, and reasoned argument, the group sought to promote public agency through a more realistic and politicised understanding of energy sustainability in the Brazilian context.

The sixth activity, titled **“The Climate Change Game – SOS Earth,”** was an environmental education initiative designed for 6th-grade students, aimed at fostering an understanding of the current climate scenario and promoting the adoption of sustainable behaviours. The activity was implemented through a board game in which participants began with 40 “carbon tokens.” As the game progressed, players’ scores were adjusted based on the environmental impact of their decisions, with positive or negative actions influencing their carbon balance accordingly.

“We created a game about climate change to teach the sixth graders at Escola da Vila, in an intuitive way, the risks of not being aware of climate change. We believe that it

is essential to have a form of 'environmental education' to prevent more people from being ignorant about the state of our planet." (Report, Group 6).

The main objective of the SOS Terra intervention was to engage elementary school students with content and concepts related to climate change through a playful and interactive approach. The choice of a board game format expresses the intention to bring complex themes closer to children's daily lives, making learning more accessible, engaging, and meaningful. The reception of the activity by the target audience was one of the indications of the success of the proposal: "the students were very engaged with the game, asking questions about why each of the actions on the cards mitigated or intensified the effects of climate change" (Report, Group 6). This observation demonstrates that the game stimulated participation, curiosity, and critical reflection among the students, promoting a space for dialogue and active learning. The process of making the game itself also played an important formative role, as it required the authors of the intervention to systematise and apply the scientific knowledge they had built up during the course. As they point out: "we thought about each of the 62 actions we put on the cards, which provide different concepts and events related to the theme" (Report, Group 6), which shows a significant effort at didactic and conceptual translation. The students recognise that "all this knowledge was generated and replicated from the climate change course classes we had" (Report, Group 6), which reveals the critical and creative appropriation of the content covered.

Thus, the activity's objectives were articulated on two levels: on the one hand, to mobilise scientific knowledge in an accessible way for a younger audience, and on the other, to consolidate and apply the authors' own learning through the creation of a pedagogical tool. The intervention demonstrates a communicative agency aimed at critical and intergenerational environmental education, contributing to the formation of aware subjects from the earliest stages of schooling.

The seventh activity explored whether climate change exacerbates social inequalities, examining the intersection between **inequality and climate impacts** and highlighting the need for inclusive public policies to facilitate adaptive mitigation. The activity resulted in the production of a main video featuring interviews on the subject, as well as a short video in the format of *reels* for dissemination on social networks.

"[...] we decided to choose the theme 'How climate change is related to the worsening of social inequalities', in order to cover both the scientific and social sides" (Report, Group 7)

The activity's central objective was to deepen understanding of the relationship between climate change and social inequality, promoting a critical approach that links climate justice, public policies, and collective engagement. The proposal materialised in the production of a documentary, whose purpose was not limited to disseminating information but to the ethical and political mobilisation of the public. Based on an interview with an expert, the students sought to show that "the knowledge passed on [...] reinforces the urgency of inclusive and equitable public policies" (Report, Group 7), with an emphasis on the importance of considering "the resilience of affected communities" (Report, Group 7). The intervention recognises that the impacts of climate change are not homogeneous, affecting historically vulnerable groups more intensely, which requires responses that promote equity in mitigating and adapting to climate effects. In this sense, the documentary was conceived as a pedagogical and political instrument capable of "not only informing but also inspiring and raising awareness of conscious actions" (Report, Group 7), aimed at fostering a broader understanding of the connections between the climate crisis and social justice. The

intervention aimed to foster an engagement that transcends passive observation, translating knowledge into action and reframing the understanding of the connection between climate and social justice as a shared commitment to sustainability and equity.

In this way, the activity's objectives are directly aligned with the aims of the pedagogical proposal as a whole by promoting critical, situated science education aimed at social transformation. The audiovisual format enabled the reach of a broader and more diverse audience. At the same time, the approach adopted showed sensitivity to the structural dimensions of the climate crisis, demonstrating the group's conceptual maturity and ethical commitment to promoting socio-environmental justice.

The eighth and final intervention explored the psychological impacts of the climate crisis, with a particular focus on **climate anxiety** among children and adolescents, groups considered more vulnerable than adults and older individuals in this regard. The project culminated in the production of a mini-documentary featuring interviews with students, in which emotional responses and coping mechanisms related to climate change were examined and discussed.

"Our group thought it would be interesting to do some research and work on the impacts of climate change and how the media propagates it on people's lives and psychology. These were the main factors that motivated this project." (Report, Group 8)."

The activity's main objective was to investigate the subjective effects of climate change, with an emphasis on climate anxiety among young people, and to reflect on the mechanisms that produce and amplify these feelings in the contemporary media context. Starting from the project's initial question, the group sought to construct a balanced analysis, recognising both the existence and the limits of extreme emotional responses to climate collapse. As they state: "climate anxiety and climate denialism exist, but neither is exactly right to 'have'" (Report, Group 8), positioning themselves against polarised perspectives – of apocalyptic alarmism or complete denialism. This stance reveals an attempt to build a critical and situated view of the climate crisis, capable of mobilising responsibility without incurring emotional paralysis or disinformation.

A central aspect of the project was the critical analysis of the role of the media and social networks in intensifying these phenomena: "the intervention makes it clear [...] how the media, social networks, and newspapers can influence in large numbers the increase in climate anxiety or even climate denialism" (Report, Group 8). This reading highlights a sophisticated understanding of the cultural mediation processes that shape public perceptions of the climate crisis, with direct impacts on the psychological well-being of individuals, particularly young people. By addressing the interface between climate, subjectivity, and communication, the group proposed an intervention aimed at promoting critical awareness of the psychological effects of the environmental crisis, contributing to science education that considers both the cognitive and affective dimensions of education. The decision to produce a video featuring interviews strengthened this aim by amplifying the students' voices, fostering the collective construction of meaning, and providing a space for expressing youth concerns in the face of an uncertain future. In this way, Group 8's activity aligns with the objectives of the pedagogical proposal by combining scientific knowledge, critical analysis of culture, and strengthening subjective agency in the face of the climate crisis, thereby promoting the construction of reflective and resilient subjects.

Final considerations

Returning to our guide question: how do students mobilise scientific and political-social knowledge about climate change in communicative actions aimed at the public? These experiences highlight the potential of interdisciplinary pedagogical practices that integrate science, art, activism, digital media, and critical reflection, actively engaging students in constructing knowledge and action in response to contemporary climate challenges. The interventions revealed the students' capacity to mobilise scientific and socio-environmental concepts within public communication initiatives. The diversity of formats adopted demonstrated a keen awareness of audience specificity and an ability to mediate between academic content and accessible language.

The analysis of the course reveals that its design and execution were consistent with the formative goals of a critical science education grounded in the STS approach and CHAT. Bringing van den Akker's (2010) curricular components, this section highlights the key aspects that underscore both the relevance and the challenges of the proposed educational intervention. The course was justified by recognising the climate crisis as a central socioeconomic and environmental contradiction of our time – demanding educational responses that move beyond informational or behavioural approaches rooted in pragmatic and immediate concerns. Accordingly, the course aimed to foster the teaching and learning of scientific knowledge related to climate change and cultivate ethical and political competencies that enable students to act critically in the face of the structural social contradictions underlying the crisis. The objectives were designed to integrate conceptual understanding, critical analysis, and transformative social engagement—dimensions reflected in the students' final products and reflective writings. The teaching and learning activities fostered the active construction of knowledge. Dialogical classes, document analysis, the production of systematic records, and structured debates enabled students to engage critically with and appropriate the course content. In the second phase, the development of student-led intervention projects further enhanced learner agency, providing opportunities to apply the knowledge acquired in authentic, real-world contexts.

The role of the teacher was central to the success of the proposal. Acting as a mediator, the teacher organised the content, guided the debates, encouraged knowledge production, and supported the groups in defining and implementing the interventions. The use of diverse materials – including official documents, graphics, videos, theoretical texts, social networks, and games – made the training process more meaningful because students had to relate actual and recent data to scientific concepts. The strategy of flexible group sizes (individual, double, and larger groups) enabled different dynamics of interaction and learning.

The evaluation was both procedural and formative, involving various instruments: a written test with consultation, an intervention project, a final report, self-evaluation, and co-evaluation. This set enabled us to verify conceptual learning through objective and well-defined written questions and monitor the development of critical agency and students' reflective capacity through the reports and arguments presented in the intervention reports. Developing an intervention project and its application in 30 classes required various skills such as organisation, negotiation, articulation theory and practice, (re)planning, and communication that cannot be expressed through a written exam. Another significant outcome was strengthening student agency, understood as the capacity to adopt ethical and critical positions in response to the climate crisis, propose concrete actions, and engage with diverse social actors. This agency was

evidenced in the selection of themes, the proactive stance adopted in addressing the challenges inherent to each project, and the students' reflective analyses of both the impacts and limitations of their interventions.

Analysing student reports, self-evaluations, and teacher observations throughout the course made it possible to identify several relevant formative effects associated with the developed proposal. First, the construction of a robust conceptual repertoire on climate change and its social, political, and economic dimensions was highlighted. The students actively mobilised this repertoire during the planning and execution of the interventions, evidencing the critical appropriation of the content they worked on in class.

The growing development of the students' ability to articulate scientific knowledge in different communicative languages was also observed, demonstrating sensitivity to both thematic complexity and the contexts of the chosen target audiences. Several groups resorted to innovative and multimodal formats, such as podcasts, games, dramatisations, and short videos, which favoured engagement and stimulated the exercise of authorship.

However, we identified some limitations in the implementation of the proposal. Groups 7 and 8 experienced difficulties producing the activity, highlighting the inherent challenges associated with promoting autonomy and curricular flexibility among secondary students. This situation highlights the tension between student-centred, open-ended learning experiences and the conventional structure of school environments, which are typically designed for linear, teacher-directed, didactic sequences. All groups were required to coordinate with other teachers and disciplines to schedule classes or conduct interviews. This requirement exposed a structural difficulty within school organisations, which are often constrained by rigid schedules and standardised spaces, making it challenging to accommodate educational proposals that demand greater temporal and spatial flexibility. Even so, the students faced these obstacles creatively and were integrated into the training process as significant challenges.

Curricular proposals for teaching science in the context of climate change should integrate scientific concepts, critical analysis of the structural factors underpinning both the problems and solutions and the transformative engagement of students as active participants. Achieving this integration requires moving beyond educational models that focus solely on content transmission, instead fostering initiatives that promote collective agency, authorship, and meaningful dialogue with diverse audiences. While the course described in this study was implemented in a private school with favourable structural conditions, we argue that its underlying principles are adaptable to other educational contexts, provided local specificities are considered. Nonetheless, we emphasise that critical pedagogical practices require sufficient time, careful planning, continuous teacher training, and robust institutional support — elements that must be guaranteed by public policies genuinely committed to climate justice and social equity.

We emphasise that the proposal demonstrated significant potential for fostering a critical science education grounded in climate justice aimed at cultivating individuals capable of transforming their contexts. By integrating scientific concepts, analysing socio-environmental contradictions, and promoting communicative action guided by ethical principles, the course contributed to an educational approach that transcends the limits of traditional schooling, aligning instead with an emancipatory educational perspective.

In times characterised by denialism, the commodification of science, and the exacerbation of socio-environmental inequalities, we reaffirm the critical role of science education as a space for cultivating individuals with historical awareness and the capacity to understand, critique and transform the world they inhabit. This task is simultaneously educational, ethical, and political, calling us to continue experimenting with, systematising, and sharing curricular practices that are genuinely committed to preserving life in its diversity and the planet's collective future.

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