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Learning to explain environmental crises: A dialogic analysis of teacher professional learning between Chile and the United States

Valeria M. Cabello[1] | **Alejandra Frausto Aceves**[2] | **Daniel Morales-Doyle**[3]

[1]Facultad de Educación, Center for Integrated Disaster Risk Management (CIGIDEN), Pontificia Universidad Católica de Chile, Santiago, Chile

[2]School of Education and Social Policy, Northwestern University, Evanston, Illinois, USA

[3]Department of Curriculum & Instruction, University of Illinois Chicago, Chicago, Illinois, USA

Correspondence
Alejandra Frausto Aceves, School of Education and Social Policy, Northwestern University, Evanston, IL, USA.
Email: alejandrafrausto@u.northwestern.edu

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Abstract

Many studies and initiatives are animated by the potential for science education to intervene in the climate crisis and crises of environmental degradation and disinformation. For science teachers to learn to address these issues in their classes, their teaching must expand beyond scientific facts and face controversial social aspects. Dealing with these crises' complexity and politics implies substantial teacher education and professional development shifts. Intending to contribute to understanding how to prepare teachers to engage in critical teaching, this article describes a collaborative cross-study dialogue to analyse science teachers' artefacts. Pre-service science teachers from Chilean universities participated, creating explanations about the climate crisis and mutually giving peer feedback. Likewise, we explore the storylined relationships between local issues of industrial pollution and chemistry content written by experienced teachers who were organised in a collective around issues of environmental racism in a large city in the United States. Through our dialogue, we refined a tool for formative feedback that contributes to research and teaching on environmental crises by supporting awareness of ideological issues in climate change and sustainability education (CCSE) and pedagogies

Valeria M. Cabello, Alejandra Frausto Aceves, and Daniel Morales-Doyle contributed equally to the article's creative and writing processes.

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of hope. We discuss how teachers in different global contexts address (or not) scientific and social justice concerns within environmental problems created by extractivist economies. Our orientation is towards horizontal dialogue and epistemic humility that recognises the problematic historical relationship between our nations and moves towards imagining more just futures. We conclude by reflecting on orientations for practice to critically address climate and environmental crisis education in different stages of teacher preparation and development. We argue that through noticing controversies, possibilities, and questions, we can transcend the barriers of dominance and dichotomy between the Global South and North and between individual and collective action in climate change and sustainability education.

KEYWORDS

climate crisis, environmental justice, pedagogies of hope, science education

Key insights

What is the main issue that the paper addresses?

- This article discusses science teachers at two different career stages and in two different contexts, Chile and the US, constructing explanations of environmental crises. The emphasis is on teachers' integration of socio-political dimensions and justice-oriented approaches in climate change and environmental education.

What are the main insights that the paper provides?

- This article describes activities that prompted nuanced teacher explanations of ecological crises while showing how dialogic, transnational collaboration expanded researchers' interpretations of these teacher artefacts. It proposes an expanded framework for formative feedback and orientations for practice towards pedagogies of hope, interdisciplinary teaching, and critical engagement with environmental justice tensions.

INTRODUCTION

Many studies and initiatives are animated by the potential for science education to intervene in intertwined crises of climate change and associated disinformation campaigns (Valladares, 2022). Science educators have identified climate change as one component of a triple planetary crisis that also includes biodiversity loss and overwhelming pollution and waste (Gandolfi, 2025a; Rushton et al., 2025). Drawing on Grosfoguel (2016), Gandolfi (2025a)

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connects the triple planetary crisis to extractivist capitalism and colonialism. Indeed, scholars have increasingly been locating the origins of ecological crises in the systems of racial capitalism and extractivist colonialism that have co-constructed scientific enterprise and established epistemological hegemony (Goffe, 2025). We follow Gandolfi, and others in science education who argue that teaching about environmental crises must account for the capitalist and colonial origins and entanglements of these crises (e.g., Clark, 2024; Segura et al., 2021; Rushton et al., 2025).

Indeed, a paradigm shift is long overdue in climate change and sustainability education (CCSE) to focus on the root causes of these crises and their justice implications (Kagawa & Selby, 2010). Among the various aspects of learning to teach science differently to address these issues in science classes, teachers must deal with broader themes, methods, and purposes than have typically been part of science classes (Rushton et al., 2025; Salinas et al., 2023). Therefore, learning about CCSE in initial and continuing teacher education is a fair and necessary response to environmental inequalities declared decades ago. Moreover, to deal with environmental racism and climate justice, teachers must confront the entanglements of epistemic, economic, and political power in their local manifestations and global contexts (Gandolfi, 2024). However, in science teachers' education and professional development, the emphasis on disciplinary concepts and core practices often marginalises issues of justice and equity (Philip et al., 2019). Dealing with these crises' complexity and politics implies substantial shifts in science teacher education, professional development, and science education research (Trott et al., 2023).

An essential part of this shift is to reconsider the explanations of ecological concerns that science teachers construct during both preparation and teaching. We conceptualise explanations as artefacts of teachers' communication and reflection processes that point to the causes of phenomena and shed light on science as a human activity (Geelan, 2003). Constructing explanations and sharing these with others in the context of science education help make thinking visible among students and teachers (Sommer & Cabello, 2020). Indeed, allowing students to construct their own explanations in the classroom instead of repeating the explanation given by others (teachers, books, media) can be a transformative and emancipatory practice (Cabello & Geelan, 2024). Emancipatory actions involve self-knowledge and reflection on the causes of phenomena and effects of one's own and others' lives, and a commitment to questioning normally unquestioned power structures, and empowerment through the critique of static ideologies (Geelan, 1996).

In this article, we present a dialogic analysis of two sets of artefacts of teacher professional learning in two different contexts, Chile and the United States (US), to better understand how some of these entanglements are described by science teachers when learning to explain environmental crises. This work is based on horizontal dialogue between perspectives from the Global South and North about preparing teachers to engage in critical teaching. Specifically, we share creative ways to engage teachers at different stages of their careers and in diverse contexts. Our dialogic approach across our contexts also helped us refine orientations for feedback on teacher practice about their explanations regarding environmental crises.

THEORETICAL FRAMEWORK

To frame our analysis of teachers' explanations of the environmental crisis, we begin with the challenges inherent in teaching towards climate and environmental justice in school science. Then, we draw on literature about teachers' explanations to consider how they might factor into addressing these challenges. This implies designing opportunities for teacher professional learning that deviate from conventional approaches to science teacher education and professional development, which we describe in the final subsection here.

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Climate and environmental justice in school science

CCSE is most often situated in school science. However, compared with other contexts where CCSE occurs, science classes are less likely to address issues of justice (McGregor & Christie, 2021; Trott et al., 2023). Justice-oriented CCSE is constrained by policies, learning standards, curricula, and teachers' beliefs that divorce scientific phenomena from their socio-political contexts (Clark et al., 2020; McGregor & Christie, 2021; Rushton et al., 2025). For teachers to emphasise justice in CCSE, they must recontextualise science to address the tensions inherent in climate and environmental justice education.

While racial capitalism and colonialism are not topics typically broached in science classrooms, there is growing consensus that any thorough explanation of climate and environmental justice connects the dots between these systems of domination, extractive industry, and scientific enterprise (Clark, 2024; Gandolfi, 2025a; Rushton et al., 2025; Sezen-Barrie et al., 2025). In addition to understanding the roots of the triple planetary crisis, analysing intersecting systems of oppression is central to explaining the uneven ecological consequences. This includes the asymmetrical distribution of climate impacts on vulnerable people who have contributed least to greenhouse gas emissions (McGregor & Christie, 2021), and the social vulnerabilities of communities marginalised by socio-spatial segregation (Gran Castro, 2023). Therefore, climate justice education connects with human rights, regarding, for instance, the right to live in a safe, clean, healthy, and sustainable environment (McGregor & Christie, 2021). Moreover, many Indigenous visions of climate justice emphasise the rights of more-than-human species and communities in a changing climate (McDaid Barry et al., 2023).

The weight, complexity, and controversial character of these facets of CCSE implicate teachers in several pedagogical tensions. For example, while CCSE research emphasises student-centred curricula, teachers are central in driving lessons towards justice orientations (McGregor & Christie, 2021). While traditional CCSE often emphasises individual responsibility, a justice orientation pushes towards collective action (Clark, 2024). Another tension is the importance of focusing on local environmental justice concerns even as the triple planetary crisis must be understood in a global context (Rushton et al., 2025). Indeed, the extractive relationship established by the Global North in the Global South is a key driver and fundamental justice consideration (Gandolfi, 2025a).

Tension also exists between posing problems for students to consider and prompting students to imagine possibilities (Freire, 1970; Torres-Olave et al., 2025). Specifically, CSSE can trigger possibilities and potentials versus problems and perils (Reid, 2019), considering justice as a bridge between knowledge and action (McGregor & Christie, 2021). Teaching to inspire and sustain hope is, therefore, one of the challenges that teachers face in addressing ecological crises in the curriculum (Sezen-Barrie et al., 2025). While some studies have emphasised the potential for students to feel climate anxiety or ecophobia (e.g. Strife, 2012), others have argued, and even demonstrated, that having opportunities to address environmental injustice in the curriculum can be a source of hope (Davis & Schaeffer, 2019; Jadallah et al., 2025; Cabello, 2025). In critical pedagogy, hope is closely tied to critical consciousness, where understanding how injustices have been historically constructed enables learners to envision other possible worlds (Freire, 1994). For instance, young activists find hope by learning to collectivise their sense of despair and act on it as active citizens who can trigger intergenerational learning (McGregor & Christie, 2021). Drawing on critical pedagogies, Clark (2024) created a framework for critical climate awareness as a central outcome of science education. In our previous work, we have argued that young people have a right to develop their own explanations for the current state of environmental injustices (Cabello, 2025) and that teaching about grassroots victories to ameliorate those injustices is one way to enact a collective pedagogy of hope in the face of ecological

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crisis (Morales-Doyle et al., 2025). Given that most researchers writing about climate justice education are based in the Global North and that there are very few collaborations between Global South and Global North author teams (Trott et al., 2023), this article, situated within this special issue, is one humble attempt to grapple with these tensions.

Constructing teacher explanations about climate change

Teachers' explanations in science education contexts are a common teaching practice; they are amalgams of discourse that integrate axioms, concepts, analogies, and other forms of communication in a coherent whole to evoke learning (Geelan, 2003). Explanations can also be seen as promoting a transmissive way of learning if the purpose is to share a static piece of information from one to another (Kulgemeyer & Geelan, 2024). On the contrary, considering the diverse actors' perspectives, the impacts of the topics being explained, and more importantly, the students' voices in the explaining process can shape explanations as a transformative teaching practice, especially in addressing controversial topics (Cabello & Geelan, 2024). Explanations in the science classroom can engage students in inquiry and discourse about phenomena as a dialogic approach to teaching and learning (Mercer & Howe, 2012).

Climate change is a global problem relevant to scientific and science education communities (Hestness et al., 2017). The increase in academic publications in recent decades reflects a worldwide interest in CCSE (Monroe et al., 2019); however, teachers are faced with teaching this complex phenomenon that inherently involves significant challenges (Bhattacharya et al., 2021; Lambert et al., 2012; Monroe et al., 2019). For instance, some teachers suppress personal views due to fear of students' pushback (Hannah & Rhubart, 2020; Igu et al., 2023; Sezen-Barrie et al., 2019), which might lead to depoliticised instruction to avoid controversy, limiting opportunities for critical dialogue and developing student agency (Henderson et al., 2024; Nation & Feldman, 2022). Teacher explanations predominantly focus on scientific facts and economic priorities (Kranz et al., 2022; Lowan-Trudeau, 2022). This is an issue because curriculum fragmentation and lack of explicit socio-political aspects in the explanations hinder comprehensive CCSE (Dunlop & Rushton, 2022; Greer et al., 2023; Hannah & Rhubart, 2020). Specifically, incorporating argumentation, critical discourse, and socio-scientific issues (SSI) promotes deeper engagement with socio-political dimensions (Mejía-Cáceres & Rieckmann, 2023; Pountney, 2025; Sanchez et al., 2024), as well as interdisciplinary and community-based approaches to connect global issues with local action (Ben Zvi Assaraf et al., 2024; Fuchs, 2023; Stevenson et al., 2024).

Educators have long advocated for socio-scientific issues, including environmental controversies, to be central in the science curriculum (Levinson, 2006). SSI are characterised by their complexity, meaning explanations of SSI must necessarily consider the entanglement of scientific and moral dimensions (Ke et al., 2021). Often omitted from the SSI education literature are the explicitly political dimensions of SSI and their local manifestations in global contexts (dos Santos, 2009). For these reasons, we advocate for defining, together with students, social justice science issues (SJSI) to situate SSI in socio-political and historical contexts (Morales-Doyle & Frausto, 2019). Building on dos Santos' (2009) assertion that SSI are akin to Freirean generative themes, we have shown how engagement with SJSI can contribute to students grappling with and communicating about the socio-political and scientific complexity of issues like environmental racism (Morales-Doyle, 2017). This means working towards explanations that go beyond simple cause-and-effect relationships, relying not solely on scientific evidence. It also implies a rejection of a simple polar view of politics where students consider 'both sides' of an issue. Instead, dealing with complexity means developing explanations that consider uncertainty, contingencies, historical context, and the

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various ways that power and oppression shape socioecological systems. Supporting the development of these complex explanations entails teaching strategies that incorporate participatory methods and activities that are both meaningful and personally relevant to students (Lombardi et al., 2017). For instance, teachers can facilitate deliberative discussions, interact with scientists, and design and implement community projects, which often include civic or socio-political engagement (Monroe et al., 2019; Frausto Aceves & Morales-Doyle, 2022).

CCSE research with teachers has focused on understanding beliefs, preparedness and knowledge about the climate crisis and factors that influence students' learning, such as curriculum or the length and effectiveness of professional development programmes (Bhattacharya et al., 2021; Lombardi et al., 2017). Targeted activities might improve teacher content knowledge, pedagogical skills, and confidence in addressing climate change education (Beach, 2023; Chang & Pascua, 2016; Majid et al., 2023; Matkins & Bell, 2007; Mavuso et al., 2022; Monroe et al., 2019; Pruneau et al., 2010; Sihvonen et al., 2023). Nonetheless, teacher professional development often fails to prepare them for climate change education's political and ethical complexities (Beasy et al., 2023; Boon, 2023; Nation & Feldman, 2022), and teachers perceive a lack of systemic support (Henderson et al., 2024; Nation & Feldman, 2022; Oranga et al., 2023). Ongoing, collaborative, and context-specific professional development is essential for transformative teacher agency (Filippaki, 2022; Fowler, 2024; Rushton et al., 2024), and efforts must be intentionally directed to support teachers in curriculum integration (Salinas et al., 2023). In sum, there is more research needed regarding teacher learning about climate change and sustainability issues (Beach, 2023; Hestness et al., 2017), and how we can help pre-service teachers develop greater awareness of the ideological issues in CCSE (Goller & Rieckmann, 2022; McGregor & Christie, 2021).

Design for teacher professional learning and feedback

Professional learning and development are ongoing in a teacher's career, from pre-service to retirement. In the design and implementation of professional development for science teachers along this spectrum of professional practice, professional learning is not unidirectional; it can be situated within a more dynamic context (Luft & Hewson, 2014). Opfer and Pedder (2011) theorise that teacher professional learning should be conceived of as the reciprocal influencing of the teacher, the school, and the learning activity. Further, they contend that 'What should determine which set of activities, systems, structures, and so on are necessary for teacher learning to occur should depend on an understanding of the different ways that these elements interact with each other, with contexts, and with characteristics of individual teachers' (p. 394).

An essential resource towards addressing the different and multiple needs of science teachers within a variety of contexts and goals in professional learning is feedback. In a study with in-service science teachers designed to follow them two years after the professional learning intervention, Palmer (2011) found that increases in teacher self-efficacy were attributed to the cognitive mastery of teaching science alongside in situ feedback. From a 'flourishing' perspective that also accounted for the emotions and well-being of teachers, Harwood and Froehlich (2017) found, for instance, that seeking feedback as a professional practice generally decreases as teachers achieve higher educational status. However, cultural implications exist about how flourishing is defined, who gets put in positions to flourish, and how feedback might be perceived as existing alongside deficits rather than strengths (Harwood & Froehlich, 2017). Auld et al. (2013) address culture and their own ongoing professional learning with PSTs by conceiving the back and forth of assignment(s) and feedback as cultural gifts (Luke, 2008). Further, they argue that when pedagogical gifts are

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shared in 'dialogue with a critical friend as a way of attempting to improve our "ideological becoming"' we help sustain hope 'irrespective of the challenging times that contextualise our professional learning' (Auld et al., 2013, p. 42).

METHODS

Research and collaboration context

This article reports on the collaborative cross-study discussions among three researchers from two independent studies involving (1) a group of Chilean pre-service secondary science teachers and (2) a group of experienced high school science teachers in the United States. We engaged in critical and collaborative dialogue about these two contexts of teacher learning, offering a different way to approach CCSE to better understand how some of these entanglements are described by science teachers when learning to explain environmental crises.

We followed an action-research methodology in both, which facilitated establishing common views and shared research purposes. Action-research can be generally considered a methodology that seeks to guide action towards the transformation of the realities under study (Lewin, 1946). Moreover, a participatory approach was adopted because it was coherent with both projects that were driven by hopes of pedagogical change to address environmental justice (Thiollent, 2011).

Chilean pre-service teachers (PSTs)

The context of the constructed data with Chilean PSTs was based on an action-research design, using peer learning and feedback to explore simulated explanations about the climate crisis in role-playing with classmates. The small groups (3–5 participants for feedback) were configured between student teachers of physics, chemistry, and biology. The idea of discussing with other discipline classmates their micro-lesson proposals was intended to promote a more complex understanding of the inter and transdisciplinary needs for interactions between knowledge fields when teaching socio-scientific issues (McLeod & Nagatsu, 2018).

At the time of sharing the datasets between authors, 13 PSTs had participated. We considered the explanatory process constructed by PSTs in the final year of teacher preparation programmes. They belonged to two universities in Santiago, the capital of Chile and had little contact with environmental issues and environmental education in their prior courses. Indeed, in University 1, only biology students had two prior courses oriented towards content knowledge about vegetal and animal biodiversity. In University 2, chemistry and biology PSTs had a course about ecology and another about ethics and citizenship. Neither university offered environmental-related courses to physics PSTs.

Micro-lessons led by PSTs were supported by a series of podcasts produced by Valeria Cabello and colleagues regarding science teaching for sustainability in the climate crisis and other topics (Cabello et al., 2024). The PSTs listened to a draft version and provided feedback to the team, which was incorporated into a revised version of the material.

Chicago in-service teachers

The artefacts from the US context were generated by teachers participating in a collective of secondary science teachers, scientists, community organisers, youth, and educational

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researchers who came together to support projects in Chicago chemistry classrooms that address environmental racism. We have referred to this as a 'more-than-teacher collective' because it centres the work of science teachers while also deeply involving other constituency groups who contribute to science education (Morales-Doyle et al., 2025). This is an example of *teacher solidarity co-design* because we worked together to design curriculum to learn in ways that each constituency group could not on their own (Philip et al., 2022). As part of ongoing participatory design meetings, teachers engaged in several explanatory and speculative writing prompts, followed by rounds of feedback, to inform the big picture of curriculum planning. These writing prompts included writing a *storyline* about the problem of heavy metal contamination in the city, writing a vision of an idealised classroom project that addresses that problem, and writing a *problem-posing letter* inviting students to participate. For this article, we analysed artefacts from the storyline writing prompt contributed by five high school chemistry teachers with teaching experience ranging from 7 to 13 years at the time of the artefact writing. We focused on this writing prompt because the resulting artefacts explicitly include explanations of environmental injustice, the focus of our dialogic conversations across the Chilean–US contexts.

Global South/North solidarities

In the spirit of this special issue, we came together to learn with each other in reciprocal and dialogic ways, focused on how teachers learn to construct explanations about complex environmental problems. We were aware of the difficulty of integrating socio-political dimensions into scientific explanations of the climate and environmental crisis. Our dialogic and reciprocal approach contrasts the uneven power dynamics that characterise relationships between the Global South and Global North generally and between our two locales, in particular. In fact, there is a troubled history of unidirectional academic influence moving from the US to Chile during the dictatorship that characterised Chilean politics during the last quarter of the twentieth century and continues to have lasting impacts (Bockman, 2019). Augusto Pinochet infamously took power in Chile in a US-backed coup of the democratically elected Chilean government and President Salvador Allende in 1973. During Pinochet's two-decade dictatorship in Chile, neoliberalism dominated the country's economic transformation. This shift was influenced by a group of Chilean economists trained at the University of Chicago and others who promoted extreme free-market ideologies. These ideas transformed the Chilean economy when they took leadership positions, such as in academia, creating one of the early test sites of neoliberalism (Bockman, 2019). The US-educated reformers became known as 'the Chicago boys', and their policies have come to represent how neoliberal capitalism drives inequality and the privatisation of public services. The Chicago Boys also serve as a prominent example of how US academic institutions are complicit in US aggression in Latin America and ideological domination around the world. In terms of the themes of this paper, the US domination of the global economy bears a great deal of responsibility for climate and environmental crises caused by extractive capitalism (Klein, 2015).

In contrast, almost five decades after these geopolitical events, our collaboration has been grounded in solidarity, mutual respect, and the fundamental assumption that we have much to share and learn with each other across our contexts to understand environmental problems created by extractive economies. In fact, addressing global environmental challenges requires this kind of reciprocal exchange. The three authors began working together in 2018 during a short visit by Alejandra Frausto Aceves and Daniel Morales-Doyle to Chile. We were initially introduced by a mutual friend and colleague who had been facilitating grassroots exchanges between educators in our two countries who were organising against

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the overuse of high-stakes standardised testing. Our collaboration deepened when Frausto Aceves and Morales-Doyle spent 6 months living and learning in Chile in 2024.

Consistent with these commitments, our approach to this study mirrored a horizontal method for teaching where our methodological decisions were made in dialogue (Shor & Freire, 1987). This approach started with identifying rich data across our two locations that we could examine together. The research had an exploratory scope based on a collaborative cross-study of two contexts. From the Chilean context, Cabello shared de-identified versions of PSTs' explanations in peer role-playing about the climate crisis, part of a more extensive ongoing professional learning sequence. In the US, Frausto Aceves and Morales-Doyle shared de-identified versions of in-service teachers' storyline writing about urban heavy metal contamination. This activity was also part of a larger professional learning sequence. We selected these two sets of teacher artefacts for their shared emphasis on explaining urgent ecological problems. One of the limitations of this research is that we analysed two different types of teachers' explanations, oral versus written and produced by teachers in diverse stages of professional development. This issue did not allow us to base our analysis on direct comparisons of the teachers' artefacts between the two contexts. Nonetheless, sharing the de-identified data sets allowed us to dialogue and co-construct a common orientation, as an example of how research concerns can be reimagined as possibilities when typical barriers are challenged.

Although the joint analysis of oral explanations from one context and written explanations can be considered a limitation in the study, our goal was not a direct comparison. Oral communication of scientific concepts enables direct, spontaneous interaction with paralinguistic elements, whereas written communication is more static and requires more planning (Castañeda et al., 2024). This difference relates to students where different modes differentially support learning. For instance, Lachner and colleagues (2018) found that providing written explanations was more effective than giving oral explanations in helping students to organise the content of the explanations, and generating oral explanations was more beneficial to developing transferable knowledge. Nonetheless, in teacher education, the difference is minimised when working with simulations of (or precursors to) classroom explanations, in our case, with in-service and pre-service teachers, because both groups prepared a plan for their explanation. Likewise, the analysis did not consider the paralinguistic and interactional elements, which are the dimensions that vary the most between oral and written modes. Still, rather than a direct comparison, our research purpose was to identify generative features of the professional learning activities and refine orientations for providing teachers with feedback.

When presenting our respective data sets to each other, Cabello shared a few orientations for the practice of constructing explanations that she and her collaborators in Chile developed as part of formative peer feedback between the PSTs. Considering the difficulties in integrating the social aspects of climate change explanations for this group, these orientations were: the presence of a controversy or controversial aspect in the explanation; including implications and/or consequences of the phenomena, and the value of questioning or criticising diverse aspects of socio-scientific themes and identifying the social actors, entities or other people involved (Table 1).

Similarly, Frausto Aceves and Morales-Doyle presented a set of tensions that guided their work with in-service teachers, including tensions between posing problems and imagining possibilities, focusing on disciplinary concepts and real-world contexts, and lessons that are teacher-driven versus student-centred. Given our transnational dialogic approach, we added a fourth tension – between a local and global framing of environmental concerns. Together, we decided to begin coding across the two data sets by positioning teachers' explanations using Cabello's initial orientations and these four sets of tensions as codes.

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TABLE 1 Initial three orientations for analysing PSTs' explanations.

Controversy	Implications	Questioning
1. Raise a controversy. 2. Invite students to identify and develop arguments about a controversy through discussion, deliberation, debate, or dialogue 3. Express values of respect and listen actively to diverse visions or forms of knowledge (intercultural, ancestral, different from one's own)	1. Explain the phenomenon only from its causes, not in relation to its implications and consequences 2. Express the phenomenon's consequences in natural, social, cultural, and environmental contexts 3. Promote a critical stance or discussion among students about the causes and consequences of phenomena	1. Questions do not explicitly invite further questioning or critique 2. Express or incite questions that invite further questioning of socio-scientific themes 3. Questions permit the identification of social actors, entities, and/or people to promote comprehension of socio-scientific issues

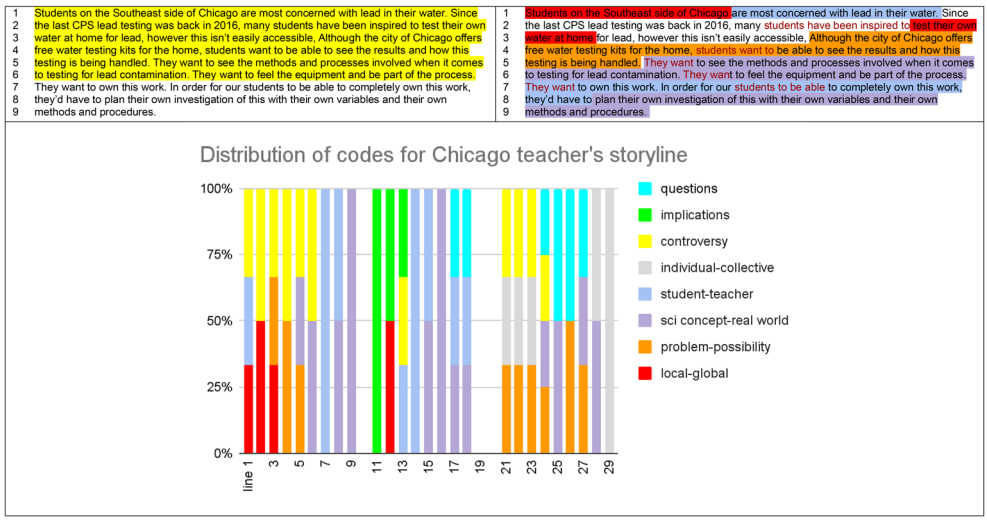

FIGURE 1 Example of fine-grained textual analysis.

Each researcher coded for both the orientations and the tensions separately. Figure 1 presents an example of the fine-grained analysis of each explanation narrative that shaped our dialogues. In this illustrative example, after coding an artefact line by line, Frausto Aceves brought both orientation and tension codes together to discuss her coding with the group. Shown on the top left is an excerpt, lines 1 through 9, of an in-service Chicago teacher's artefact. The first six lines were coded with a controversy orientation. On the right of that are the same nine lines coded for tensions. Beneath both, a visual was created by Frausto Aceves to overlap both orientations and tensions in preparation for the group sense making. After each researcher coded, we confirmed our coding dialogically and shared some emerging insights. For instance, as we looked across the two data sets, we began noticing how questions, one of three focal orientations, surfaced with the tensions of problem/possibilities and the tension of science concepts and real-world issues. We also noticed how the tension of orienting the explanation towards discipline and inter/transdisciplinary showed up alongside controversy in both the PSTs' and in-service teachers' artefacts. This noticing led to the expansion of both the orientations

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and the tensions. Through our discussion, a new individual and collective/social tension was elevated. Additionally, as shared in the findings below, a fourth level of complexity emerged as the tensions were situated within the orientations for practice as shown in Table 2. In this process of dialogic analysis, we shared insights and concerns about how teachers learn to explain ecological topics. The categorisation and interpretation of the data were the main techniques (Thiollent, 2011). The trustworthiness of the analysis was established by dialogue, trust, and agreement between the three authors.

Through our dialogic analysis of these teacher artefacts, we were able to exchange strategies tailored to our distinct educational contexts, fostering early professional development between peers and promoting collaborative practices among in-service teachers and diverse stakeholders regarding environmental problems. This analytical process was the most suitable in epistemological terms, because we avoided the truth monopolisation and conceived it as an open position, with no imposition of pre-determined procedures but emergent from a dialogue between people with diverse knowledge (Thiollent, 2011).

FINDINGS

In this section, we identify features of professional development activities that emerged as generative and synergies that we found between our work, contributing to redefining the tools for the analytical framework. We illustrate the salience of these professional development activities and synergies between our methods with examples from teachers' explanation artefacts.

Professional learning activities

Professional learning towards addressing climate justice in the classroom represented a challenge for the participants in both contexts. Teachers' work from each context was sophisticated and yet illustrated the difficulty of attending to socio-political aspects of climate and environmental crisis within scientific explanations. Our dialogic analysis of teacher artefacts provided an opportunity for us to share strategies that worked in our different contexts to support early professionalism between peers (Chile) and in-service teacher collaborative activities with diverse actors (US).

We focus on explanations that the content of the climate crisis podcast (Chile) and the storyline writing prompt (US) might influence. The topics covered in the podcast for the Chilean PSTs were myths about the climate crisis, the differences between natural phenomena and socio-natural disasters, the role of human rights, eco-injustices, energy poverty, and interdisciplinary teaching methods. What is notable about these topics is that they provided openings for teachers without extensive coursework about ecological issues to consider the socio-political causes and implications. In the collective of teachers in the US, we began a day-long check-in co-design meeting in the middle of the third school year of working together with the following writing prompt:

> Write a description of the problem of heavy metal contamination in Chicago. Explain the associated chemistry that is most important to understand. Reflect on how learning this chemistry might raise awareness, spark critical consciousness, inspire hope, and/or inform action.

What is notable about this prompt is that it explicitly asks teachers to attend to key content (‘associated chemistry that is most important to understand’) and to socio-political context,

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TABLE 2 Expanded orientations for practice with tensions in 4th dimension.

Controversy	Implications	Questioning
1. Raise a controversy 2. Invite students to identify and develop arguments about a controversy through discussion, deliberation, debate, or dialogue 3. Express values of respect and listen actively to diverse visions or forms of knowledge (intercultural, ancestral, different from one's own)	1. Explain the phenomenon only from its causes, not in relation to its implications and consequences 2. Express the phenomenon's consequences in natural, social, cultural, and environmental contexts 3. Promote a critical stance or discussion among students about the causes and consequences of phenomena	1. Questions do not explicitly invite further questioning or critique 2. Express or incite questions that invite further questioning of socio-scientific themes 3. Questions permit the identification of social actors, entities, and/or people to promote comprehension of socio-scientific issues
4. Controversies are multifaceted, with more than two sides, including local and global viewpoints. Explanations integrate diverse values, visions, disciplinary knowledge, or other ways of knowing to provide nuance	**4. Encourage socio-political action among students and teachers by normalising the responsibility of individuals to contribute to collective goals (individual and systemic)**	**4. Questions support the movement between learning scientific concepts and understanding real-world problems with the goal of taking action and/or imagining possibilities**

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including goals of 'rais[ing] awareness, spark[ing] critical consciousness, inspir[ing] hope, and/or inform[ing] action'. Indeed, we note how the prompt asks for both problem and possibility framed in a local setting, but not excluding the broader context. In this way, both tasks ask teachers to address and extend from the scientific explanation into the socio-political context, a key feature of justice-oriented CCSE (Sezen-Barrie et al., 2025).

Our analysis showed that the podcasts and storyline writing prompt supported teachers in each context to address socio-political considerations in their explanations about environmental crises. One common way for teachers to do this was by considering the entanglement of science and industry in creating these crises. For example, a PST in Chile led the following discussion with their colleagues after they listened to the podcasts on climate crisis, sustainability, and human rights:

PST: Why are we talking about an increase in CO_2 in the greenhouse effect or in the atmosphere?
Colleague (playing the role of a student): Because there is an increase in CO_2…
PST: Yes?
Colleague: …for the high levels of emissions that they generate, like…
PST: Perfect.
Colleague: …based on the industrial system.
PST: Industrial system, yes, very good, right? But in talking about carbon footprints, we are going to associate any emission that we could have, from the personal level to the industrial level. Right? That is about the carbon footprint, right?

In this brief exchange during a microteaching experience, a line of questioning by a PST leads one of their colleagues (playing the role of a student) to raise the 'industrial system' as the source of high levels of greenhouse gases. The PST connects this back to carbon footprints, explaining how their consideration of the carbon footprint will include micro contributions on the individual level all the way up to industrial factors. This exchange avoids a common pitfall of teaching about the climate crisis and environmental degradation, where students are prompted to focus only or primarily on their individual contributions to the problem. While the industrial system is not linked here with systems of racial capitalism or colonialism, there is an opening created by the systemic thinking. As pre-service teachers working together in Chile, where the economy has been heavily dependent on the extractive industry, we see opportunities for this co-constructed explanation to consider broader socio-political contexts more explicitly. Similarly, a teacher in the US wrote about the industrial history of their city as being responsible for the issue of heavy metal contamination, as is presented in the following excerpt:

> Chicago is historically an industrial city. The human incorporation of heavy metals like lead into products that people use/or historically have used has created contamination in soil, water, air, and many buildings and consumer products that are still used today. We are often exposed unknowingly to these metals by companies/governments that are claiming to keep us safe. Exposure to these metals varies from pipes and old paint to pollution and consumer products like some children's juices and cosmetics. Impacts are often felt most heavily on young children whose development can be compromised. There is also an important component, especially in Chicago, around environmental racism and who we value and prioritise.

In this explanation, written by an experienced teacher, we see a counterpoint to another common pitfall of CCSE, which does not consider justice, that is, a failure to address how

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the impacts of these problems are experienced in unequal ways across intersectional social categories like age, race, and gender (Morales-Doyle et al., 2019). Here, the teacher's explanation of the issue of heavy metal contamination begins with the role of industry and emphasises the vulnerability of young children and the role of environmental racism in the unequal distribution of the impacts of this problem. We do not attribute these features of the teachers' explanations to the podcast or the writing prompt in isolation. Instead, we highlight how, within a broader plan for teacher learning and within a community of practice that explicitly valued climate and environmental justice, these features supported teachers' inclusion of these ideas alongside canonical scientific concepts in their explanations in ways that do not shy from controversy. This is visible in the previous excerpts and more explicit in those that follow. Across both contexts, teachers connected environmental catastrophes with extractive capitalist production in historical contexts. In these same examples, teachers also considered or implied how pathways forward must consider knowledge systems other than science. Again, without inferring causation or trying to make direct comparisons, we see congruity between the podcast content and writing prompts in the ways in which teachers expanded beyond scientific ideas in their explanations. The following exchange illustrates one way in which Chilean PST dealt with these themes:

PST: The production increased… the production increased. And, together with the increase in production, the existence of businesses that used carbon as a source of energy also increased, and that generated lots of greenhouse gases. And, at the key moment when the Industrial Revolution began, we saw an exponential increase in the average temperature. The Earth always passes through cycles of temperature that will increase and decrease, and that is natural; it is normal. But, when, for the impact of humans, this is seen to accelerate, the problems start. Now, what do you all think that we can do to prevent, at the root, this increase in the temperature of the Earth that we were talking about?

Colleague: it's not enough to get the gas out of here, teacher?

PST: What do you think? How is it that if companies stop producing, the gas will leave immediately? But will it go naturally, or is there some process that must happen?

Colleague: I don't know, teacher. I don't know for sure.

PST: Look, if we get rid of the businesses, it could be some benefit, but we would also have to see how we can eliminate the greenhouse gases, and for that, there is a natural process called photosynthesis that can help us to trap the carbon dioxide, that businesses can generate, in the plants and liberate oxygen. Do you have any questions? Now, I would like for us to think about it: should this be done only with sciences, or do you all think that other areas can intervene in the discussion of climate change?

At the beginning of this short discussion, the PST begins the explanation with the increase in capitalist production facilitated by the Industrial Revolution as the underlying cause of the rise in greenhouse gases, which is the disciplinary explanation for climate change. They do not place the Industrial Revolution in broader contexts of Euro-American colonialism or racial capitalism. But they do implicitly lean into the present political context by including a reference to one of the common fallacies used by climate deniers (natural cycles of Earth's temperature) before shifting the focus to what can be done to prevent further increases. When their line of questioning did not solicit much participation from their colleagues, this PST first referenced another canonical scientific idea, photosynthesis, as a way for removing carbon dioxide from the atmosphere before shifting to ask whether areas besides the sciences might be helpful in addressing climate change.

An excerpt from a US teacher's storyline writing weaves together an extractive economy and overwhelming pollution with atomic properties, transportation, worker safety, and residential segregation:

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> Raw materials were brought in, which, at the root of their atomic properties, proved cost-effective to work with but, at the same time, deadly to the worker. These raw materials, which were transported via the network of roads and rail, which divided (instead of unified) a city, not only poisoned the people's bodies from within but also their minds as they provided outlets for easy separation and segregation of classes and groups of people. Today, many of these systems remain, and although industry may have changed, laws may have changed, thoughts may have changed, the contamination remains like a stain that cannot be washed out.

In this segment of writing, the teacher alludes to toxic metals like lead and mercury that continue to be used for their advantageous properties even as their toxicity has caused immeasurable damage to the health of workers who mined, handled, and processed them and to surrounding environments and the people and other beings who live there. In referring to transportation networks dividing a city, the teacher is describing how the construction of railways and highways served to literally concretise lines of residential racial segregation that undergird environmental racism in many cities around the world. There is even a reference to the racist ideology of segregation as metaphorically toxic. In lamenting the persistence of these pollutants in the last line, this teacher alludes to the tensions of "acting in a permanently polluted world" (Liboiron et al., 2018). In our analysis of this segment, in light of the focus of this article, we also noticed a missed opportunity for global connections and international solidarities to be part of the storyline. In the present context, many of the raw materials that fuel rampant consumption in the Global North are extracted in the Global South, to the detriment of ecological conditions there (Gandolfi, 2025b). Our dialogic approach inspired us to learn from each other's activities for teacher professional development related to explaining the triple planetary crisis in science class. Specifically, examples shared here pointed us to possibilities for pushing teachers to elaborate the role of extractive North–South relations in their explanations, thus opening space for solidarities. Noticing opportunities for expansion or connection like this in many of the teachers' explanations prompted us to consider how we might learn from each other to provide feedback capable of pushing teachers' explanations further, at any stage of their careers.

Expanded orientations for feedback on teacher practice

Our data – including the excerpts of teachers' explanations presented in the previous subsection – showed substantial evidence of sophistication and a willingness to push beyond the norms of science education to deal with environmental and climate justice issues. It also provided a glimpse into how these teachers worked to make sense of complex themes and phenomena as preparation for engaging their students with the same. As teacher educators, we were challenged by reviewing these explanations to provide the kind of feedback that could support teachers across a range of experiences, contexts, and criticality as they continue to refine and expand explanations like these. To that end, we noticed an opportunity to add a fourth dimension to the orientations for practice from Cabello's research group by incorporating the tensions articulated in professional development settings by Frausto Aceves and Morales-Doyle. Table 2 shows the fourth dimension added to the orientations introduced in Table 1.

The fourth dimension of orientations to controversy explicitly names consideration of transdisciplinary knowledge and multiple viewpoints (including local and global perspectives) in developing nuanced introductions of controversies in science classes. The fourth dimension of orientations to implications of the climate crisis prompts teachers to normalise socio-political engagement among youth and adults as individuals capable of contributing to broader collective goals and movements. The fourth dimension of orientations to questioning

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encourages prompting students to move back and forth between canonical scientific concepts and real-world controversies and to imagine possibilities and even take action to move towards those possibilities.

Taken together, we view the fourth dimension of these orientations as encouraging teachers to develop explanations of complex and potentially overwhelming environmental and climate justice issues that could reflect pedagogies of hope and engagement. For example, Chilean PSTs had this exchange:

PST: Now, what can we do to address the climate crisis? Do you all have any ideas? For example, for many people there is a myth that says that the climate crisis is so, so big that we can't do anything to confront it. What do you all think about that? Is this myth true? What do you all believe? Is it true or not?
Colleague: Maybe one person can't stop it– many people. Maybe not me, maybe us.
PST: Yes – perfect.
Colleague: Yes, I believe that by taking action and contributing, like they say, their fair share, they can make a slightly stronger change that can counteract what is happening.

This exchange reflects a turn towards hope and engagement that is based on collectivity rather than changing individual behaviours. A similar spirit of collectivity was reflected in an excerpt from a story written by a US teacher about the curriculum the group was developing together.

> I think this unit inspires hope because it reveals complex structures that are often hidden – while learning science that may allow solutions and safety to be prioritised. It has also been seeing students share their vision of how the world should work, what changes need to be made, and how we as humans should live together with each other and the Earth.

Hope is connected with critical consciousness by emphasising teaching about 'complex structures that are often hidden'. It also connects teaching about climate and environmental justice by providing space for students to imagine alternative possibilities for human relationships with each other and the Earth.

DISCUSSION AND IMPLICATIONS

Formal schooling mostly occurs in local contexts, and at the secondary level, is organised mainly by disciplines. In this paradigm, CSSE happens mostly in science classrooms but does not often include explicit climate and environmental justice orientations (Rushton et al., 2025; Trott et al., 2023). These justice orientations imply locating the triple planetary crisis in political and historical contexts of colonialism, racial capitalism, and extractive industry, which have created vastly unequal consequences in the Global North and Global South (Clark, 2024; Gandolfi, 2025a; Sezen-Barrie et al., 2025). Therefore, if justice-oriented CSSE is to happen in our schools, science teachers must develop the ability to explain complex socioecological phenomena in historical, political, and global contexts.

Learning to orient towards justice through reciprocal South–North dialogue

The history between Santiago de Chile and Chicago in the United States of America is marked by a historically uneven relationship of neoliberal academic influence. Elsewhere, we have

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written that good intentions will not lead us to the ethical and just worlds we deserve. Our will must be fortified with practice and humility to build pluralistic solidarity communities (Morales-Doyle et al., 2025; Tolbert et al., 2023). Thus, we saw an opportunity to restore dialogues in the frame of science teachers' professional learning. We aimed to learn together about developing transdisciplinary pedagogies of hope to contribute, through science education, to a just transition from extractive to more sustainable, circular, and just economies. In this article, we adopted horizontal dialogue that recognises the problematic historical relationship between our nation-states and between scientific enterprise and extractive industries.

Therefore, we used a dialogic process of analysing artefacts produced by secondary science teachers in Chile and the US in professional learning settings that were quite different. We did not compare apples to oranges to make universal claims. Instead, we sought to take small steps together, imagining imperfectly and researching with humility to make a road by walking (Freire & Horton, 1990). Rather than limit collaboration across the Global South and Global North to perfectly aligned projects or data sets, we suggest that these sorts of small moves are valuable. We learned from each other about innovative activities for supporting teachers' construction of explanations and identified synergies between aspects of these explanations and the inherent tensions of this pedagogical work. We used these synergies to refine our orientations towards practice, which we anticipate will be useful in providing teachers with feedback and promoting feedback between them using these orientations that motivate addressing controversy (Henderson et al., 2024; Nation & Feldman, 2022), multiple actors, community-driven approaches to connect global issues with individual action (Ben Zvi Assaraf et al., 2024; Fuchs, 2023; Stevenson et al., 2024) and questions that promote hope and agency (Sihvonen et al., 2023). Following Freire (1994), we understand that hope emerges when learners are aware of how injustices have historically been constructed, allowing them to see how other worlds are possible. Feedback orientations, particularly in the fourth dimension of our orientations, 'Implications', aim to make visible socio-political engagement not as an isolated individual action, but as a contribution to broader collective movements. This connects with the argument that teaching about grassroots victories to improve environmental injustices is a way to promote collective pedagogies of hope.

The teachers' explanations we analysed across both contexts showed sophisticated thinking and a willingness to raise controversies around extractive industries, discuss the implications of unjust environmental impacts, and ask questions about historical contexts. The development of critical climate awareness (Clark, 2024) requires more than the understanding of scientific concepts; it involves analysing intersectional systems of oppression and their unequal ecological consequences. Our expanded orientations provide scaffolding for teachers and their students to develop this kind of awareness, relying, for example, on mutual support through peer feedback and considering pedagogy as a gift (Luke, 2008). By sharing the activities which prompted these explanations, we as authors also learned new creative approaches for seeding complex teacher explanations about socioecological crisis. At the same time, teachers in neither context explicitly mentioned global systems of oppression like colonialism or racial capitalism nor did they make connections between Global North and Global South contexts that characterise extractive industry and the uneven implications of planetary crisis. This suggests further research that draws more attention to these themes, as well as in our work with science teachers at the pre-service and in-service stages. One possibility for enhancing this aspect of our work is to create opportunities for science teachers to dialogue with each other and co-construct explanations for the triple planetary crisis across contexts, like Chicago and Santiago. We encourage new research exploring international dialogues and feedback with teachers collaborating from the Global South and North, for instance, in online international PD groups connecting diverse contexts and trajectories. This idea might serve as a practical orientation and/or research possibility.

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Our dialogic approach also helped us to identify synergy in our existing work that will encourage us to move forward in our local contexts. Throughout the learning artefacts we have presented here, it was clear that including social justice and environmental equity dimensions was crucial for the participants, which are in tension in the normative curriculum (Pérez-Rodriguez et al., 2024). Thus, this call cannot be answered only by teachers but also by policymakers (Rushton et al., 2025), for instance, in national frameworks for teacher preparation. The PSTs moved from the classical explanations about causes and effects, descriptions and justifications towards discursive practices that are not teacher-directed or presented as a static artefact with dialogic utterances of multiple facets, points of view and impacts. They show us essentially learning to communicate pathways (Geelan, 1996). Therefore, rather than asking teachers and students to construct explanations of decontextualised phenomena or depoliticised socio-scientific issues (SSI), justice-oriented CCSE might begin by explicitly defining social justice science issues or SJSI (Tolbert et al., 2023; Morales-Doyle, 2017). This approach resonates with the possibility for supporting classroom explanations as a liberatory practice that builds on young people's own analysis of socioecological crises (Cabello & Geelan, 2024; Cabello, 2025). It involves not considering 'both sides' of an issue, but rather developing explanations that consider uncertainty, contingencies, historical context, and the various ways in which power and oppression shape social-ecological systems.

Possibilities for peer feedback towards just explanations in CSSE

Indeed, we have proposed an analytical framework to approach science teachers' explanations that expands the way of analysing this common teaching practice, which might have been traditionally considered transmissive and hierarchical (Kulgemeyer & Geelan, 2024). This framework directly addresses some of the pedagogical tensions identified in the CCSE literature (Clark, 2024; McGregor & Christie, 2021). For example, local–global tension awareness might help construct teacher explanations about climate and environmental crises by enhancing the incorporation of multiple level and geographic perspectives. Likewise, by inquiring about explanations as a science teachers' core practice, we intend to re-centre equity and justice in teacher–student dialogic discourse (Philip et al., 2019). Specifically with respect to the triple planetary crisis, we see opportunities to move teachers towards critical climate awareness (Clark, 2024) about the triple planetary crisis (Gandolfi, 2025a; Rushton et al., 2025) in ways that match the political clarity of activists (McGregor & Christie, 2021).

We see peer feedback on explanations of the ecological crisis as a key strategy for this movement. Opfer and Pedder (2011) theorise that teacher professional learning should be conceived of as the reciprocal influencing of the teachers, the school, and the learning activities. The analytical framework we have advanced here, with a fourth dimension that emerged from our dialogue, can serve in the practice for reframing explanations about the complexities of teaching the climate crisis, including a perspective of social justice, global citizenship, the ethics of belonging to this world, and responsibility in a geopolitical context. Thus, it can become an adaptable set of orientations to guide teachers' noticing, a prompt to think differently between peers and a tool for formative feedback. Sharing the complexities of teaching SJSI with peers and other actors could be a nurturing process if addressed with respect, consideration and humility. This is an example of how we can help pre-service (and experienced) teachers develop greater awareness of the ideological issues in CCSE (Goller & Rieckmann, 2022; McGregor & Christie, 2021). Teachers in different career stages or trajectories of development can support transdisciplinary approaches and open spaces of hope that transcend the barriers of dominance between junior and senior colleagues, social or human environmental sciences versus physical sciences, or the dichotomy between

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the global North and South (Rodrigues et al., 2020). Moreover, teachers are challenged to consider and confront the entanglements of epistemic, economic, and political power in their local manifestations and global contexts (Gandolfi, 2024).

As Rushton et al. (2025) point out, this transformation cannot be left solely to teachers, but requires changes in education policies and national curricular frameworks. Teacher preparation frameworks should explicitly include competencies to address justice-oriented CCSE, recognising that the artificial disconnection between scientific phenomena and their socio-political contexts (Clark et al., 2020) must be challenged in both teacher education and curriculum standards so that they permeate the classrooms of the present and future. We emphasise supporting the development of pedagogies of hope, continuous teacher professional development, and peer collaboration. This is a collective endeavour in which activists, educational communities, academics, and diverse stakeholders must participate.

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CONFLICT OF INTEREST STATEMENT

We declare there are no relevant financial or non-financial competing interests to report.

DATA AVAILABILITY STATEMENT

We use data that includes sensitive information about individuals and student teachers. Access to these data is restricted to researchers working on the research projects and will require a security clearance process after 5 years.

ETHICS STATEMENT

Ethical aspects for research with people were followed under protocol number 210728001 ethical board approval and UIC IRB 2017-0373.

ORCID

Valeria M. Cabello https://orcid.org/0000-0001-6190-9187
Alejandra Frausto Aceves https://orcid.org/0000-0002-0959-471X
Daniel Morales-Doyle https://orcid.org/0000-0002-9425-2158

REFERENCES

Auld, G., Ridgway, A., & Williams, J. (2013). Digital oral feedback on written assignments as professional learning for teacher educators: A collaborative self-study. *Studying Teacher Education*, *9*(1), 31–44. https://doi.org/10.1080/17425964.2013.771575

Beach, R. (2023). Addressing the challenges of preparing teachers to teach about the climate crisis. *The Teacher Educator*, *58*(4), 507–522. https://doi.org/10.1080/08878730.2023.2175401

Beasy, K., Jones, C., Kelly, R., Lucas, C., Mocatta, G., Pecl, G. T., & Yildiz, D. (2023). The burden of bad news: Educators' experiences of navigating climate change education. *Environmental Education Research*, *29*(11), 1678–1691. https://doi.org/10.1080/13504622.2023.2238136

Ben Zvi Assaraf, O., Dawson, V., Eilam, E., Gokpinar, T., Goldman, D., Naugauker, N., Eka Putri, G. A. P., Subiantoro, A. W., Tolppanen, S., White, P., Widdop Quinton, H., & Dillon, J. (2024). Climate change education implementation: The voices of policymakers, professional development providers, and teachers in five countries. *International Journal of Science Education*, *47*(2), 191–213. https://doi.org/10.1080/09500693.2024.2314572

Bhattacharya, D., Carroll Steward, K., & Forbes, C. T. (2021). Empirical research on K-16 climate education: A systematic review of the literature. *Journal of Geoscience Education*, *69*(3), 223–247. https://doi.org/10.1080/10899995.2020.1838848

14693518, 0, Downloaded from https://berj-journals.onlinelibrary.wiley.com/doi/10.1002/berj.70078 by Cochrane France, Wiley Online Library on [19/12/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Bockman, J. (2019). Democratic socialism in Chile and Peru: Revisiting the "Chicago boys" as the origin of neoliberalism. *Comparative Studies in Society and History*, *61*(3), 654–679. https://doi.org/10.1017/S0010417519000239

Boon, H. J. (2023). Applications of codes of teacher ethics in the context of anthropogenic climate change. *Teachers and Teaching*, *30*(3), 341–360. https://doi.org/10.1080/13540602.2023.2282490

Cabello, V. M. (2025). Children's explanations in at-risk zones: Fostering hope through science education in Quintero-Puchuncaví Bay. *Pedagogies: An International Journal*, *20*(1), 93–119. https://doi.org/10.1080/1554480x.2024.2397537

Cabello, V. M., & Geelan, D. (2024). Teachers' scientific explanation practices: Opportunities for equity. In S. Romero-Contreras, I. García-Cedillo, & L. M. Moreno-Medrano (Eds.), *Intercultural and inclusive education in Latin America: (International Perspectives on inclusive education, Vol. 24)* (pp. 127–139). Emerald Publishing Limited. https://doi.org/10.1108/S1479-363620240000024009

Cabello, V., Zúñiga, C. G., Amador Valbuena, C., Manrique, F., Albarrán, M. J., & Moncada-Arce, A. (2024). We are not being taught sustainable citizenship! *LUMAT: International Journal on Math, Science and Technology Education*, *12*(2). https://doi.org/10.31129/lumat.12.2.2135

Castañeda, D., Paredes, M., López, N., & Padilla, M. (2024). Comunicación oral y escrita en el contexto de la investigación científica. *Polo del Conocimiento*, *9*(2), 850–860. https://doi.org/10.23857/pc.v9i2

Chang, C. H., & Pascua, L. (2016). Singapore students' misconceptions of climate change. *International Research in Geographical and Environmental Education*, *25*(1), 84–96. https://doi.org/10.1080/10382046.2015.1106206

Clark, H. F. (2024). Critical climate awareness as a science education outcome. *Science Education*, *108*(6), 1670–1697. https://doi.org/10.1002/sce.21896

Clark, H. F., Sandoval, W. A., & Kawasaki, J. N. (2020). Teachers' uptake of problematic assumptions of climate change in the NGSS. *Environmental Education Research*, *26*(8), 1177–1192. https://doi.org/10.1080/13504622.2020.1748175

Davis, N. R., & Schaeffer, J. (2019). Troubling troubled waters in elementary science education: Politics, ethics & black children's conceptions of water [justice] in the era of Flint. *Cognition and Instruction*, *37*(3), 367–389. https://doi.org/10.1080/07370008.2019.1624548

dos Santos, W. L. P. (2009). Scientific literacy: A Freirean perspective as a radical view of humanistic science education. *Science Education*, *93*(2), 361–382. https://doi.org/10.1002/sce.20301

Dunlop, L., & Rushton, E. A. (2022). Putting climate change at the heart of education: Is England's strategy a placebo for policy? *British Educational Research Journal*, *48*(6), 1083–1101. https://doi.org/10.1002/berj.3816

Filippaki, A. (2022). Building a collective school culture to achieve education for sustainability: The contribution of teachers' perceptions. *Open Journal of Social Sciences*, *11*(4), 19–38. https://doi.org/10.4236/jss.2023.114003

Fowler, T. A. (2024). Addressing climate change anomie in teacher education. *Northwest Journal of Teacher Education*, *19*(1), 1–23. https://doi.org/10.15760/nwjte.2024.19.1.4

Frausto Aceves, A., & Morales-Doyle, D. (2022). More than civil engineering and civic reasoning: World-building in middle school Stem. *Bank Street Occasional Paper Series*, *48*, 13–32. https://doi.org/10.58295/2375-3668.1473

Freire, P. (1970). *Pedagogy of the oppressed*. Continuum.

Freire, P. (1994). *Pedagogy of hope*. Continuum.

Freire, P., & Horton, M. (1990). *We make the road by walking: Conversations on education and social change*. Temple University Press.

Fuchs, T. T. (2023). A framework for climate change education in critical geography. *Geography*, *108*(2), 95–100. https://doi.org/10.1080/00167487.2023.2217632

Gandolfi, H. (2024). (Re)considering nature of science education in the face of socio-scientific challenges and injustices. *Science & Education*, *1*, 1–27. https://doi.org/10.1007/s11191-024-00536-w

Gandolfi, H. (2025). It looks as if they threw the entire periodic table into the river: A decolonial perspective for chemistry education in the context of environmental justices. *Science Education*, *109*(6), 1652–1668. https://doi.org/10.1002/sce.21984

Gandolfi, H. (2025b). (Re) considering science education in the face of environmental injustices in pre-and post-pandemic worlds: Insights from a critical-decolonial nature of science. In C. Moura (Ed.), *A sociopolitical turn in science education: Towards post-pandemic worlds* (pp. 71–93). Springer. https://doi.org/10.1007/978-3-031-78586-3_4

Geelan, D. (1996). Learning to communicate: Developing as a science teacher. *Australian Science Teachers Journal*, *42*(1), 85.

Geelan, D. (2003). Teacher expertise and explanatory frameworks in a successful physics classroom. *Australian Science Teachers Journal*, *49*(3), 22–32.

Goffe, T. L. (2025). *Dark laboratory: On Columbus, the Caribbean, and the origins of the climate crisis*. Doubleday.

14693518, 0, Downloaded from https://berj-journals.onlinelibrary.wiley.com/doi/10.1002/berj.70078 by Cochrane France, Wiley Online Library on [19/12/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Goller, A., & Rieckmann, M. (2022). What do we know about teacher educators' perceptions of education for sustainable development? A systematic literature review. *Journal of Teacher Education for Sustainability*, *24*(1), 19–34. https://doi.org/10.2478/jtes-2022-0003

Gran Castro, J. A. (2023). Denaturalizing climate change: Environmental injustice and social vulnerability in contexts of socio-spatial segregation in Mexico. *International Journal of Disaster Risk Reduction*, *94*, 103802.

Greer, K., King, H., & Glackin, M. (2023). 'Standing back'or 'stepping up'? Exploring climate change education policy influence in England. *British Educational Research Journal*, *49*(5), 1088–1107. https://doi.org/10.1002/berj.3888

Grosfoguel, R. (2016). Del extractivismo económico al extractivismo epistémico y ontológico. *Revista Internacional de Comunicación y Desarrollo*, *1*(4), 33–45.

Hannah, A. L., & Rhubart, D. (2020). Teacher perceptions of state standards and climate change pedagogy: Opportunities and barriers for implementing consensus-informed instruction on climate change. *Climatic Change*, *158*(3), 377–392. https://doi.org/10.1007/S10584-019-02590-8

Harwood, J., & Froehlich, D. E. (2017). Proactive feedback-seeking, teaching performance, and flourishing amongst teachers in an international primary school. In M. Goller & S. Paloniemi (Eds.), *Agency at work. Professional and practice-based learning, vol 20* (pp. 425–444). Springer. https://doi.org/10.1007/978-3-319-60943-0_21

Henderson, J. A., Drewes, A., Trauth, A., Thayer, N., & Hemsley, K. (2024). How geography and politics shape teachers' engagement with climate change science standards. *Environmental Education Research*, *5*, 1–24. https://doi.org/10.1080/13504622.2024.2441198

Hestness, E., McGinnis, J. R., Breslyn, W., McDonald, R. C., & Mouza, C. (2017). Examining science educators' perspectives on learning progressions in a climate change education professional development program. *Journal of Science Teacher Education*, *28*(3), 250–274.

Igu, N. C. N., Ogba, F. N., Nwinyinya, E., Eze, B., Ogar, J. N., & Obih, S. O. (2023). How teacher's climate change belief influences classroom management practices for students' climate change awareness in nigerian schools. *Polish Journal of Environmental Studies*, *32*(3), 2657–2668. https://doi.org/10.15244/pjoes/159429

Jadallah, C. C., Barry, K. M., Germinaro, K., & Barry, N. (2025). Building the world anew: On critical hope in climate change education. *Environmental Education Research*, *1–17*, 1–17. https://doi.org/10.1080/13504622.2025.2498941

Kagawa, F., & Selby, D. (2010). *Education and climate change: Living and learning in interesting times (Vol. 30)*. Routledge.

Ke, L., Sadler, T. D., Zangori, L., & Friedrichsen, P. J. (2021). Developing and using multiple models to promote scientific literacy in the context of socio-scientific issues. *Science & Education*, *30*(3), 589–607. https://doi.org/10.1007/s11191-021-00206-1

Klein, N. (2015). This changes everything: Capitalism vs the climate. *Environmental Communication*, *11*(1), 136–138. https://doi.org/10.1080/17524032.2016.1196534

Kranz, J., Schwichow, M., Breitenmoser, P., & Niebert, K. (2022). The (un)political perspective on climate change in education—A systematic review. *Sustainability*, *14*(7), 4194. https://doi.org/10.3390/su14074194

Kulgemeyer, C., & Geelan, D. (2024). Towards a constructivist view of instructional explanations as a core practice of science teachers. *Science Education*, *108*(4), 1034–1050. https://doi.org/10.1002/sce.21863

Lachner, A., Ly, K.-T., & Nückles, M. (2018). Providing written or Oral explanations? Differential effects of the modality of explaining on students' conceptual learning and transfer. *The Journal of Experimental Education*, *86*(3), 344–361. https://doi.org/10.1080/00220973.2017.1363691

Lambert, J. L., Lindgren, J., & Bleicher, R. (2012). Assessing elementary science methods students' understanding about global climate change. *International Journal of Science Education*, *34*(8), 1167–1187. https://doi.org/10.1080/09500693.2011.633938

Levinson, R. (2006). Towards a theoretical framework for teaching controversial socio-scientific issues. *International Journal of Science Education*, *28*(10), 1201–1224. https://doi.org/10.1080/09500690600560753

Lewin, K. (1946). Action research and minority problems. *Journal of Social Issues*, *2*(4), 34–46.

Liboiron, M., Tironi, M., & Calvillo, N. (2018). Toxic politics: Acting in a permanently polluted world. *Social Studies of Science*, *48*(3), 331–349. https://doi.org/10.1177/0306312718783087

Lombardi, D., Bickel, E. S., Brandt, C. B., & Burg, C. (2017). Categorising students' evaluations of evidence and explanations about climate change. *International Journal of Global Warming*, *12*(3–4), 313–330. https://doi.org/10.1504/IJGW.2017.084782

Lowan-Trudeau, G. (2022). Climate change curricula in Alberta, Canada: An intersectional framing analysis. *Northwest Journal of Teacher Education*, *17*(3), 1–12. https://doi.org/10.15760/nwjte.2022.17.3.10

Luft, J. A., & Hewson, P. W. (2014). Research on teacher professional development programs in science. In *Handbook of research on science education* (pp. 903–924). Routledge.

Luke, A. (2008). Pedagogy as a gift. In J. Albright & A. Luke (Eds.), *Pierre Bourdieu and literacy education* (pp. 68–91). Routledge.

14693518, 0, Downloaded from https://berj-journals.onlinelibrary.wiley.com/doi/10.1002/berj.70078 by Cochrane France, Wiley Online Library on [19/12/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

MacLeod, M., & Nagatsu, M. (2018). What does interdisciplinarity look like in practice: Mapping interdisciplinarity and its limits in the environmental sciences. *Studies in History and Philosophy of Science Part A*, *67*, 74–84. https://doi.org/10.1016/j.shpsa.2018.01.001

Majid, N., Marston, S., Johnson, J. D., & Happle, A. (2023). Reconceptualising preservice teachers' subject knowledge in climate change and sustainability education: A framework for initial teacher education from England. *Sustainability*, *15*(16), 12237. https://doi.org/10.3390/su151612237

Matkins, J. J., & Bell, R. L. (2007). Awakening the scientist inside: Global climate change and the nature of science in an elementary science methods course. *Journal of Science Teacher Education*, *18*(2), 137–163.

Mavuso, M., Olawumi, K., Khalo, X., Kafu-Quvane, B. P., & Mzilikazi, B. (2022). Implementation of teacher capacitation programs to integrate climate change education: The case study of geography teaching in south African secondary schools. *International Journal of Learning, Teaching and Educational Research*, *21*(11), 73–86. https://doi.org/10.26803/ijlter.21.11.5

McDaid Barry, N., Bang, M., Bruce, F., & Barajas-López, F. (2023). 'Then the nettle people won't be lonely': Recognizing the personhood of plants in an indigenous STEAM summer program. *Cognition and Instruction*, *41*(4), 381–404. https://doi.org/10.1080/07370008.2023.2220852

McGregor, C., & Christie, B. (2021). Towards climate justice education: Views from activists and educators in Scotland. *Environmental Education Research*, *27*(5), 652–668. https://doi.org/10.1080/13504622.2020.1865881

Mejía-Cáceres, M. A., & Rieckmann, M. (2023). Political discourses as a resource for climate change education: Promoting critical thinking by closing the gap between science education and political education. *Sustainability*, *15*(8), 6672. https://doi.org/10.3390/su15086672

Mercer, N., & Howe, C. (2012). Explaining the dialogic processes of teaching and learning: The value and potential of sociocultural theory. *Learning, Culture and Social Interaction*, *1*(1), 12–21. https://doi.org/10.1016/j.lcsi.2012.03.001

Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2019). Identifying effective climate change education strategies: A systematic review of the research. *Environmental Education Research*, *25*(6), 791–812. https://doi.org/10.1080/13504622.2017.1360842

Morales-Doyle, D. (2017). Justice-centered science pedagogy: A Catalyst for academic achievement and social transformation. *Science Education*, *101*(6), 1034–1060. https://doi.org/10.1002/sce.21305

Morales-Doyle, D., Childress Price, T., & Chappell, M. J. (2019). Chemicals are contaminants too: Teaching appreciation and critique of science in the era of Next Generation Science Standards (NGSS). *Science Education*, *103*(6), 1347–1366. https://doi.org/10.1002/sce.21546

Morales-Doyle, D., & Frausto, A. (2019). Youth participatory science: A grassroots science curriculum framework. *Educational Action Research*, *29*(1), 60–78. https://doi.org/10.1080/09650792.2019.1706598

Morales-Doyle, D., Frausto Aceves, A., Chappell, M. J., & Childress Price, T. (2025). History, hope, and humility in Praxis: Co-Determining priorities for professional learning with content area teachers. *Cognition and Instruction*, 1–30. https://doi.org/10.1080/07370008.2025.2555820

Nation, M., & Feldman, A. (2022). Climate change and political controversy in the science classroom. *Science Education*, *31*(6), 1567–1583. https://doi.org/10.1007/s11191-022-00330-6

Opfer, V. D., & Pedder, D. (2011). Conceptualising teacher professional learning. *Review of Educational Research*, *81*(3), 376–407. https://doi.org/10.3102/0034654311413609

Oranga, J., Gisore, B., Areba, G., & Info, A. (2023). Barriers to transformative climate change education: Mitigation and resilience-building. *International Journal of Social Sciences*, *3*(3), 389–396. https://doi.org/10.53625/ijss.v3i3.6631

Palmer, D. (2011). Sources of efficacy information in an inservice program for elementary teachers. *Science Education*, *95*(4), 577–600. https://doi.org/10.1002/sce.20434

Pérez-Rodríguez, F., Guerrero, G. R., & Donoso-Díaz, S. (2024). Scientific culture in the normative and curriculum documents of Initial Teacher Education in Chile. *Cultural Studies of Science Education*, *19*(2), 459–479. https://doi.org/10.1007/s11422-024-10226-2

Philip, T. M., Pham, J. H., Scott, M., & Cortez, A. (2022). Intentionally addressing nested systems of power in schooling through teacher solidarity Co-design. *Cognition and Instruction*, *40*(1), 55–76. https://doi.org/10.1080/07370008.2021.2010208

Philip, T. M., Souto-Manning, M., Anderson, L., Carter Andrews, D., Stillman, J., & Varghese, M. (2019). Making justice peripheral by constructing practice as "core": How the increasing prominence of core practices challenges teacher education. *Journal of Teacher Education*, *70*(3), 251–264. https://doi.org/10.1177/0022487118798324

Pountney, R. (2025). 'Let's talk about the weather': The activist curriculum and global climate change education. *British Educational Research Journal*. https://doi.org/10.1002/berj.4122

Pruneau, D., Gravel, H., Bourque, W., & Langis, J. (2010). Experimentation with a socio-constructivist process for climate change education. *Environmental Education Research*, *9*(4), 429–446. https://doi.org/10.1080/1350462032000126096

14693518, 0, Downloaded from https://berj-journals.onlinelibrary.wiley.com/doi/10.1002/berj.70078 by Cochrane France, Wiley Online Library on [19/12/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Reid, A. (2019). Climate change education and research: Possibilities and potentials versus problems and perils? *Environmental Education Research*, *25*(6), 767–790. https://doi.org/10.1080/13504622.2019.1664075

Rodrigues, C., Payne, P. G., Grange, L. L., Carvalho, I. C. M., Steil, C. A., Lotz-Sisitka, H., & Linde-Loubser, H. (2020). Introduction: "New" theory, "post" north-south representations, praxis. *The Journal of Environmental Education*, *51*(2), 97–112. https://doi.org/10.1080/00958964.2020.1726265

Rushton, E. A. C., Dunlop, L., & Atkinson, L. (2024). Fostering teacher agency in school-based climate change education in England, UK. *Curriculum Journal*, *36*(1), 253. https://doi.org/10.1002/curj.253

Rushton, E. A. C., Walshe, N., & Johnston, B. J. (2025). Towards justice-oriented climate change and sustainability education: Perspectives from school teachers in England. *The Curriculum Journal*, *3*, 1–18. https://doi.org/10.1002/curj.322

Salinas, I., Fernández, M. B., Johnson, D., & Bastías, N. (2023). Freire's hope in radically changing times: A dialogue for curriculum integration from science education to face the climate crisis. *Cultural Studies of Science Education*, *18*, 21–39. https://doi.org/10.1007/s11422-023-10157-4

Sanchez, J. M., Picardal, M., Fernandez, S., & Caturza, R. R. (2024). Socio-scientific issues in focus: A meta-analytical review of strategies and outcomes in climate change science education. *Science Education International*, *35*(2), 119–132. https://doi.org/10.33828/sei.v35.i2.6

Segura, D., Morales-Doyle, D., Nelson, S., Levingston, A., & Canales, K. (2021). Sustaining community-school relationships around shared visions of climate justice and science teaching. *Connected science Learning*, *3*(5). https://doi.org/10.1080/24758779.2021.12318702

Sezen-Barrie, A., Shea, N. A., & Borman, J. H. (2019). Probing into the sources of ignorance: Science teachers' practices of constructing arguments or rebuttals to denialism of climate change. *Environmental Education Research*, *25*(6), 846–866. https://doi.org/10.1080/13504622.2017.1330949

Sezen-Barrie, A., Windschitl, M., & Nxumalo, F. (2025). Transformative climate and environmental education for a just future. *Science Education*, *109*, 715–721. https://doi.org/10.1002/sce.21963

Shor, I., & Freire, P. (1987). What is the "dialogical method" of teaching? *Journal of Education*, *169*(3), 11–31. https://doi.org/10.1177/002205748716900303

Sihvonen, P., Herranen, J., Uusi-Äijö, V., & Aksela, M. (2023). Teacher agency in using students' questions in climate change education. *Interdisciplinary Journal of Environmental and Science Education*, *19*(4), 1–13. https://doi.org/10.29333/ijese/13724

Sommer, M., & Cabello, V. M. (2020). Andamios de retiro gradual. Parte 2: Apoyos a la construcción de explicaciones en ciencia primaria. *Estudios Pedagógicos*, *46*(1), 269–284. https://doi.org/10.4067/S0718-07052020000100269

Stevenson, R. B., Whitehouse, H., & Field, E. (2024). Teaching climate justice education holistically in schools. *Oxford Research Encyclopedia of Education*, *9*, 1791. https://doi.org/10.1093/acrefore/9780190264093.013.1791

Strife, S. J. (2012). Children's environmental concerns: Expressing ecophobia. *The Journal of Environmental Education*, *43*(1), 37–54. https://doi.org/10.1080/00958964.2011.602131

Thiollent, M. (2011). Action research and participatory research: An overview. *International Journal of Action Research*, *7*(2), 160–174.

Tolbert, S., Frausto Aceves, A., & Torres-Olave, B. (2023). From false generosity to true generosity: Theorizing a critical imaginary for science education. In M. Wallace, J. Bazzul, M. Higgins, & S. Tolbert (Eds.), *Reimagining Science Education in the Anthropocene* (Vol. *2*). Palgrave Macmilllan. https://doi.org/10.1007/978-3-031-35430-4_10

Torres-Olave, B., Avraamidou, L., & Moura, C. B. (2025). Critical imagination for transformative agency: Pedagogies for science teacher education. *Science Education*, *109*, 1484–1498. https://doi.org/10.1002/sce.21970

Trott, C. D., Lam, S., Roncker, J., Gray, E. S., Courtney, R. H., & Even, T. L. (2023). Justice in climate change education: A systematic review. *Environmental Education Research*, *29*(11), 1535–1572. https://doi.org/10.1080/13504622.2023.2181265

Valladares, L. (2022). Post-truth and education: STS vaccines to re-establish science in the public sphere. *Science & Education*, *31*, 1311–1337. https://doi.org/10.1007/s11191-021-00293-0

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14693518, 0, Downloaded from https://berj-journals.onlinelibrary.wiley.com/doi/10.1002/berj.70078 by Cochrane France, Wiley Online Library on [19/12/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License