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Climate Change Education through a Social Justice Framework: A necessary first step towards solving the climate crisis

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Introduction

Global climate change is one of – if not the most – urgent crises of the modern era. Every decade in the past forty years has been successively hotter than any decade preceding it since the 1850s, a historically unprecedented acceleration resulting in heat waves, droughts, cyclones, and other weather and climate extremes (IPCC, 2021). Barring profound and swift decreases in greenhouse gas emissions, recent models predict an increase of at least 1.5˚C greater than pre-industrial measures (IPCC, 2021), surpassing the previously established international maximum goal (UNFCCC, 2015). As should be all too clear, dramatic yet rapid changes must be made now to preclude the increasing severity, frequency, and duration of climate-related disasters accompanying every additional degree of warming (IPCC, 2021). However, despite this ostensibly bleak picture, room for hope exists: scientists posit that reaching net-zero carbon emissions by approximately 2050 would arrest and plateau global warming at around 1.5˚C,

forestalling the sharp escalation in risks associated with increases exceeding that threshold (Plumer & Fountain, 2018).

Additionally, climate change is increasingly acknowledged as an issue of social justice. The impact of the Global North on the planet's "atmospheric commons" impinges most forcefully on those populations who have contributed the least to climate change, the generally less resilient nations of the Global South (Kagawa & Selby, 2011). On a subtler but no less acute scale, people of color and low-income households within more industrialized nations are more likely to experience the negative consequences of climate change, such as extreme heat, major flooding, and air pollution (Saraswat & Kumar, 2016). In both the global and national spheres, a shared theme emerges: a dominant group is responsible for a growing disequilibrium in human flourishing and development. Such infringements on rights, opportunity, and equity are key features of social injustice and thus climate change should be treated as a social justice issue in addition to a scientific phenomenon (The San Diego Foundation, 2016). While technological progress may find a way to mitigate rising temperatures, ocean acidification, and forest fires, it will not destroy the mechanisms by which climate change arose and as such will not prevent other calamities in the future. If the root causes of climate change still exist, what is to say dominant societal and political actors won't manifest another global environmental crisis? Situating climate change in the social arena better enables individuals, groups, nations, and the global community to work from the metaphorical ground up instead of "fiddling around the edges".

In all possible scenarios resulting from climate change – good and bad, environmental and social – youth will inherit the earth and face the ramifications of previous generations' actions.

As such, young people are often considered the current or future leaders in solving climate change, positioned as saviors who will swoop in to overcome the sordid legacy of environmental passivity (Rousell & Cutter-Mackenzie-Knowles, 2020). Counterintuitively then, there exists a relative dearth of opportunities for children and adolescents to learn effectively about global climate change, and to refine and express concerns, understandings, and "freedom dreams" about climate change and potential solutions (Rousell & Cutter-Mackenzie-Knowles, 2020; Love, 2019). Although youth are more likely than adults to believe that climate change is occurring, still less than 1 in 5 American minors self-report a high degree of climate science knowledge (Washington Post Kaiser Family Foundation, 2019) and misconceptions related to climate change drivers among youth remain common (Jeffries et al., 2001; Leiserowitz et al., 2014).

Perhaps as a result, climate change education (CCE) increasingly takes center stage in mitigation, adaptation, and resilience efforts. Expansion of CCE research reflects this proliferating interest, with the number of CCE-related articles published between 2010 and 2015 more than ten thousandfold times that published in the 1990s (Monroe et al., 2017). Even the United Nations' Education, Scientific, and Cultural Organization (UNESCO) has declared education not only "integral" to climate change solutions but "the most powerful element" in equipping societies with the understandings, attitudes, and skills needed to handle global climate challenges (UNESCO, 2018). However, a lag appears to exist between the expansion in research and on-the-ground CCE curricula. Schools presently act as the primary location in which youth receive CCE (Jeffries et al., 2010), yet as recently as 2019, only 42% of surveyed teachers reported talking about climate change with their students (NPR/Ipsos, 2019), a proportion less than the 75% found in a 2016 national survey (Plutzer et al., 2016). In congruence with these

concerning trends, student reports of the amount of climate knowledge disseminated in classrooms has actually declined within the last decade (Washington Post Kaiser Family Foundation, 2019; Leiserowitz et al., 2010). These facts situate the classroom as the most important and perhaps most underutilized outlet through which children and teens can develop climate literacy. Important to address then, what actually *is* climate change education, what is getting in the way of widespread implementation, and why does it provide such a promising avenue towards solving the climate crisis? CCE is so promising because, in its most ideal form, it addresses climate change at its roots and helps youth become climate literate thinkers, citizens, and activists. CCE can, should be – and in many cases, already is – a step towards a much – needed transformation in societal understanding, adaptation, and mitigation of climate change.

Forms of climate change education

Across the United States, CCE in schools takes many forms, in part due to a lack of standardized curricular recommendations and learning outcomes. Although the range of poor to successful CCE programs is a spectrum – and depends on one's definition of "success" – CCE programs generally fall into three tiers. At the base level, CCE can manifest as the transfer of climate science facts from teacher to student or the use of climate change as a backdrop to learning widely applicable competencies such as close reading and the scientific method (Monroe et al., 2017). One systematic analysis of CCE literature found that more than 90% of reviewed studies reported a focus on scientific knowledge and cognitive understanding, with approximately half of all studies reporting this as the *primary* approach (Rousell & Cutter-Mackenzie-Knowles, 2020). However, researchers know that information or "science literacy" alone will not engender the eco-conscious behaviors needed to make a meaningful difference in climate change. The "knowledge-deficit model" of human behavior argues that lack

of action is directly attributable to lack of knowledge (Knutti, 2019). If true, the remedy seems clear: by gaining knowledge about climate change, individuals' concern will grow, and they will then become motivated to act. However, time and time again, studies demonstrate that reality is not this neat: there is often no discernible correlation between knowledge and pro-environmental choices (Busch, 2017.; Knutti, 2019; Pidgeon & Fischhoff, 2011; Vainio & Paloniemi, 2013). So, while information may be a prerequisite for action, research indicates that information alone is not sufficient. Whether this disconnect is primarily due to social, political, structural, or economic barriers – or more likely an amalgamation of all four – has yet to be established conclusively. Regardless, it remains clear that the "deficit model" does not best capture the causes of environmental inaction and thus should not alone inform CCE pedagogy; a pure focus on information dissemination is simply inadequate to inspire actionable change.

Accordingly, the second tier of CCE transcends a matter-of-fact conveyance of information and attempts to encourage good "environmental citizens" (Ferreira, 2019), a tactic that seems to appear in about a quarter of CCE literature (Rousell & Cutter-Mackenzie-Knowles, 2019). To illustrate this middling tier of CCE, one program designed and tested with high school students in New York defined "environmental action" as the *individual*, daily choices one makes that can have a positive impact on the health of the environment(McNeill & Vaughn, 2012, p. 376). The curriculum in question imparted climate science and addressed "the misconception that students often have that their personal actions do not impact the environment" with lessons focusing on such activities as local tree plantings and "personal energy audits" (McNeill & Vaughn, 2012, p. 379). Furthermore, when conducting post-surveys, the study's authors deemed their curriculum successful based on an increase in small-scale acts like limiting automotive transportation and

conserving water (McNeill & Vaughn, 2012). While these deeds may ameliorate carbon emissions slightly, the scale of reductions needed far exceeds what can be accomplished by individual citizens (Mann, 2019).

To be clear, personal and local efforts are an important aspect of well-rounded climate action; however, many argue against CCE paradigms that stop at simplistic one-off individual acts, such as recycling or turning off the lights when one leaves a room (Ferreira, 2019; Robottom & Hart, 1995; Stevenson et al., 2017). The implicit assumption often conveyed is that through these actions the problem is solved and thus personal obligation is exhausted: "substitution of all the incandescent bulbs in the houses of the developed world will not resolve the problem unless measures are taken in the diverse areas that now constitute Western lifestyle" (González-Gaudiano & Meira-Cartea, 2009, p. 16). Unfortunately, the above case example is not unique in this regard; when CCE does go beyond the hard science, content has historically tended to home in on changing the behavior of the student, rather than on rethinking and transforming whole societies (Ferreira, 2019). Increasingly, the promotion of individual choices is seen as a Band-Aid on a bullet hole, an inadequate measure aimed at deflecting attention away from big polluters and the global reliance on fossil fuels (Mann, 2019). The common "business as usual" approach with its "concomitant fixation on ameliorative technology" constrains CCE from unpacking the hegemonic economic model and social order that underlie climate change in the first place (Kagawa & Selby, 2010, p. 8).

Of late, trailblazers in science education argue that CCE involves a more fundamental rethinking and dismantling of current structures, calling for a holistic approach that integrates the psychosocial, ethical, cultural, and purely *human* aspects of climate change (Kagawa & Selby,

2010; Stevenson et al., 2017). In essence, under this framework, CCE involves learning in risky, uncertain, and rapidly changing times. Powerful CCE builds upon the distribution of climate science and creates opportunities for students to develop analytical thinking skills valuable for engaging with a constantly evolving situation (Stevenson et al., 2017). Powerful CCE demands focus on critically examining the causes of climate change to determine, advocate for, and actually enact appropriate responses that target the deep-seated roots of climate injustice. Powerful CCE seizes this moment – likely a turning point in history – to "think about what really and profoundly matters, to collectively envision a better future, and then to become practical visionaries in realizing that future" (Kagawa & Selby, 2010, p. 4). Schools are an apt location for inciting such change because, as Shea et al. (2016) argues, they are "crucial spaces for alternative norm development" (p. 67). Despite the apparent fit between schools' power and the need for a societal reimagining, this form of CCE in schools is rarer.

Yet, exemplary curricula have been developed and implemented with promising outcomes, as in, for instance, the Lowell School. Expanding the jurisdiction of CCE to include the humanities classroom, the Lowell School in Washington, D.C. taught about climate change via an integrated humanities-science framework (Siegner & Stapert, 2020). In their year-long climate change curriculum for 5th through 8th grade, teachers utilized storytelling and narrative in conjunction with scientific information to increase student engagement; this framework enabled educators to readily address the social and political contexts pervading climate injustice because the humanities inherently incorporate real world and anthropogenic contexts (Siegner & Stapert, 2020). Not only did this pedagogical approach engender climate literacy and concern beyond that of the average American teenager or adult (Leiserowitz et al., 2011), but teachers reported that

students began proactively requesting more opportunities to take meaningful action on climate mitigation (Siegner & Stapert, 2020).

Here, one can see that large-scale societal revolution cannot revolve around the science classroom or even the acquisition of eco-friendly tips. In order to target climate change, interdisciplinary, transformative, and holistic education is essential and must occur now.

Barriers to effective climate change education

This transformative goal for CCE is unquestionably lofty, especially in the United States. And, as the previous section laid out, numerous barriers to CCE stand in the way of a truly transformative pedagogy. From stumbling blocks to seemingly insurmountable walls, barriers to CCE include the socioscientific aspect of climate change, nonexistent or inadequate educational standards, a dearth of adequate course materials and teacher preparation, and resistance from governing bodies and communities.

In terms of its socioscientific nature, climate change poses a unique challenge among STEM topics – and even diverges in significant ways from other forms of environmental education – because of its emotional charge. Even more so than ethical controversies related to deforestation or plunging biodiversity, climate change appears to profoundly resonate with moral principles and values in a way that promotes confirmation bias – the tendency to interpret novel information as aligning with previously held beliefs (Monroe et al., 2017). When engaging with climate change dialogue, individuals often feel compelled to discount information that conflicts with that espoused by their group, leading to an "echo chamber" protecting group identity (Monroe et al., 2017). Accordingly, developing CCE curricula may involve treading a fine line between increasing climate literacy and acknowledging how sociocultural positionality regulates learning and perception. Furthermore, climate change has been found to elicit strong emotional

reactions ranging from hopelessness and helplessness to guilt and anger (Cantell et al., 2019). Ojala (2012) even argues that students' coping strategies "could be as or even more important than the feelings themselves when it comes to influencing whether pupils/students will gain knowledge about climate change as well as acquire action competence" (p. 538). Encouraging coping strategies, like reappraisal techniques, that "challenge denial-like and catastrophic thinking" (Ojala, 2012, p. 556) could be highly useful for educators navigating their students' emotional responses to climate change, all the while considering academic gains and encouraging radical societal transformation.

The deeply personal identification United States citizens seem to have with their climate change outlook is both a cause and a result of the nationally high degree of climate change politicization. In many regards, climate change "remains the toughest, most intractable political issue we, as a society, have ever faced" (Kamarck, 2019). Even as scientific evidence mounts, the public has remained largely divided; swaths of people do endorse the scientific consensus, but worryingly large - and mainly conservative - groups still burrow their heads in the sand or outright repudiate established scientific knowledge (Toth, 2018). As previously discussed, awareness or concern should not be equated with action, but they are a necessary first step in the right direction, and as little as 44% of Republicans in one poll showed concern about global climate change as recently as 2018, compared to 79% of Democrats (Toth, 2018). While partisan divisions are not the end-all-be-all of climate change inaction, the sharp disparity between the main competing factions is worth keeping in mind when it comes to how, why, where, and by who CCE is implemented.

Perhaps in part due to such political gridlock, climate change was not included in any national recommendations related to science education prior to 2012. It should be noted here that the United States operates under a federalist model such that there are no national educational mandates, a fact that raises concerns for ensuring ubiquitous climate education. Still, the Next Generation Science Standards (NGSS) ushered in an era in which climate change was, for the first time, explicitly included as a topic of study in the most widely used national guideline (Busch, 2017). Written and published by the National Science Teachers Association (NSTA), the NGSS references the word "climate" within no less than nine Performance Expectations and additionally confirms human impact on climate change (NGSS Lead States, 2013). On the surface, this inclusion is a victory for legitimizing climate change consensus among the public and beginning an early instillation of climate knowledge in American youth. However, regional and school-level inconsistencies in implementation threaten to make the "standards" anything but standard. To begin, the majority of the nine climate-related Performance Expectations are included in high school earth science classes, a course seldom required for graduation (NGSS Lead States, 2013). Given that only approximately 10% of high school graduates have taken an earth science course, as many as 90% of students could graduate high school without exposure to the complete set of NGSS climate-related standards (Busch, 2017).

Furthermore, different states may pick and choose which aspects of the NGSS – if any – to incorporate into their state curricula because the NGSS is a set of *suggestions*, not a mandate. To date, 20 states have adopted the NGSS in full, a group disproportionately represented by already liberal-leaning states (NSTA, 2021; Busch, 2017). For states that have not completely adopted the CCE standards, oftentimes due to political dissent, legislative bodies and educational boards

have either disregarded the NGSS completely or modified the language related to climate science so much so as to virtually nullify its impact. For instance, the South Dakota science standards require students to ask questions to clarify about "factors that *may have* caused a change in global temperatures over the past century" (quoted in Busch, 2017, p. 7) rather than that "*have* caused" (NGSS Lead States, 2013) such changes [emphasis mine]. And about 10 states have excluded the language regarding anthropogenic climate change completely (Kagubare, 2019).

However, even setting aside such detrimental regional variations, inclusion alone is not enough to counter *how* the NGSS positions climate change in its curricular guidelines. Scholars such as Busch (2017) critique the NGSS for its privileging of ecological modernization, an optimistic framework centered on argumentation for a market-based and technological solution to climate change. The ecological modernization perspective again fails to account for the social and scientific complexity embedded in global climate change. In thinking about the NGSS, Feinstein & Kirchgasler (2015) hypothesize that climate change

> ...would be described, emphatically, as a global issue, a framing subtly reinforced in the NGSS by its placement within earth and space sciences, where biological localities such as ecosystems are swapped out for geophysical averages of temperature and precipitation. Questions about climate change—how much, where, with what consequences—would be presented as questions that science can answer, and the scientific pursuit of these answers would be portrayed as apolitical. Students in our hypothetical classroom would learn about the relationship between human behavior and climate change in terms of the carbon cycle and the burning of fossil fuels, but they would probably not be asked to think about who has historically burned and continues to burn the majority of the fuels and who, both across and within societies, is harmed most by the practice (p. 123).

Feinstein & Kirschgasler's prediction speaks to the aforementioned first and second tiers of CCE, in which teachers hedge around more touchy climate topics, addressing either the science alone or with the addition of personal choices. It would seem then, that a paradox exists in the

way in which climate change education is handled in the United States. The increasing polarization across party lines widens the chasm between those who do and don't endorse the climate science, but at the same time, a small step towards unifying standards on CCE (i.e., the NGSS) is met with depoliticization by teachers who largely avoid the socioscientific or political nature of climate change completely – that is, if they engage in CCE at all. While too much politicization is inherently detrimental to wide-scale change, a complete lack of politicization does not capture the sociocultural underpinnings of the inception and maintenance of climate change. The framing of climate change education is then at least as important as its existence if CCE is to invoke societal action and swiftly put a stop to rising atmospheric temperatures.

And a lack of adequate textbooks and other curricular materials readily available for teachers certainly does not help matters, both in terms of content and framing. Although textbook learning should not be the paradigm for engaging pedagogy, textbooks do play an important role in the science classroom, often establishing the foundation of knowledge on which more complex scientific ideas can be imparted and explored (Busch, 2017). In one study, Choi et al. (2010) investigated whether 18 topics deemed necessary to understanding climate change were covered in U.S. textbooks. About half of these concepts were entirely absent from the majority of the textbooks surveyed, textbooks that were ostensibly geared towards teaching about the earth and its properties (Choi et al., 2010). Additionally, textbooks in other academic spheres have been found to be lacking in any mentions of climate change at all; one 2019 study revealed that several widely used history and economics textbooks completely omit climate change and related topics while several actively praise fossil fuels: e.g., "Oklahoma's oil reserves are among the largest in the nation. Fossil fuels helped the United States become an industrial giant" (quoted in

Bigelow, 2018, p. 1). As if omission alone were not enough, several of the textbooks, science textbooks no less, actively provided climate misinformation through text and figures - for example, not clearly depicting the kinds and source of the radiation involved in the greenhouse gas effect (Choi et al., 2010).

This absence or distortion of information within textbooks is compounded by a persistent framing of climate science as contested. To be clear – for this cannot be stated enough – climate change is real, occurring now, and anthropogenically caused (IPCC, 2021). Current estimates place the proportion of climate scientists in agreement with these claims as 97-99% (Myers et al., 2021; Powell, 2017). However, many textbooks on climate science engage in a practice unusual for science, technology, engineering and math (STEM) resources. Typically, educational science texts present scientific concepts as facts or definitions (Busch, 2017). (Although certain other controversial issues like evolution suffer the same ambiguously worded fate; see Padian [2013] for examples). Lest one might fail to see an alternative option – that is, how else would textbooks present information? – one review found that California science textbooks were rife with modalities and indeterminate quantifiers such as "may" and "some" (Román & Busch, 2016). For example, one science text, *Issues of Life and Science,* does list climate change among eight global threats – but climate change is the only hazard to be considered a "potential threat" rather than an unmistakable one (Bigelow, 2018, p. 1). Another textbook reads "Scientists are concerned that the resulting rise in Earth's average temperature *might* alter climates and other aspects of our environment" (quoted in Román & Busch, 2016, p. 12, emphasis mine). This quote alludes to some amorphous mass of scientists who only speculate on the potential consequences of climate change, insinuating doubt and contributing to a flawed understanding of

consensus. Vague and equivocal language creates the impression of uncertainty within the scientific community at large that does not exist, an uncertainty then reflected in teachers' pedagogy of climate change.

As previously mentioned, the estimates of teachers who do educate about climate change range from three quarters (75% in 2016 according to a widely cited Plutzer et al. study) to less than half (42% according to a 2019 NPR/Ipsos poll). Even erring on the side of Plutzer et al.'s more optimistic estimate, only 54% of teachers found to engage in CCE impart the anthropogenic nature of climate change, despite the clear scientific consensus on the matter. Furthermore, as many as 31% of those same teachers are delivering mixed messages by additionally emphasizing the natural causes of current global warming while a striking 10% do not mention the consensus at all (Plutzer et al., 2016). Regional breakdowns that largely mirror political polarization paint a bleaker picture yet; teachers in some regions are far less likely to teach about climate change than national averages, a fact that often correlates with a state's failure to adopt the NGSS (Wise, 2010; Kagubare, 2019). One survey in Colorado found that 63% of educators "marginalize" the topic and 75% agreed that students should learn "both sides" (Wise, 2010). And in North Carolina, a mere 12% of teachers attribute modern climate change to anthropogenic influences (Stevenson et al., 2017). Like most aspects of CCE – and the public response to climate change in general – causality for these worrisome realities is multifaceted.

At a base level, many K-12 educators simply do not feel sufficiently knowledgeable to teach climate science and related topics, according to the National Research Council (Hestness et al., 2014). Indeed, the majority of science teachers specifically – let alone educators of other subjects or generalized elementary school teachers – had not enrolled in climate science courses

during their undergraduate education (Plutzer, et al., 2016) and likely instead utilize the same sources the general public relies on, however reputable or unreputable those sources may be (Wise, 2010; Lambert et al., 2012). Mass media TV coverage, talk radio, and the internet can all be valuable wellsprings of knowledge, allowing a lay person to freely educate themself in climate science. But such sources can also be incredibly misleading or downright teeming with disinformation; it is well-established, for example, that mass media in the United States has exaggerated the scientific controversy and downplayed human implication in the climate crisis (Busch, 2017). Self-doubt plays a role too; many teachers lack confidence in their climate science knowledge and themselves feel unprepared to educate the next generation (Wise, 2010). Indeed, Plutzer et al. (2016) revealed that a mere 45% of high-school science teachers and 30% of middle-school science teachers knew that more than 80% of the scientific community agrees about the nature of climate change's causes, a fact even more striking when one considers that the actual consensus is *at least* upwards of 97% (Powell, 2019). Common climate change misconceptions also appear to be a problem among educators, especially when it comes to the important yet intricate details. For example, pre-service and practicing teachers, like students, have been found to confuse climate with weather and erroneously link climate change to the "ozone hole" (i.e., ozone layer depletion) and air pollution (Liu et al., 2015). Thus, teachers may not be teaching the scientific consensus simply because they do not know that such a virtually unanimous view exists and they may be instilling their own common misconceptions in students, further entrenching a general imprecision in climate knowledge among the general public.

But, just as knowledge alone does not inspire widespread action, teachers' false impressions or unfamiliarity with climate science cannot account for all CCE shortcomings.

Teacher background undoubtedly influences pedagogical choices and the manner in which curriculum is selected and implemented (Ross et al., 1996). In terms of climate change, the relationship between teachers' attitudes and their actions largely mirrors that of the general public. Just as political affiliation powerfully predicts climate action and ability to assimilate new information (Latkin et al., 2021), teachers' ideological backgrounds play an important role in their pedagogy. Research has repeatedly shown that political leaning more accurately predicts educators' CCE approach than any measure of conceptual knowledge or education (Plutzer et al., 2016; Plutzer & Hannah, 2018; Khalidi & Ramsey, 2021). In one study, for example, those that had been teaching "both sides" of the climate change "controversy", also espoused a belief in smaller government (Plutzer, et al., 2016). Another study indicated that endorsement of statements associated with "hierarchical-individualism" – a conservative ideology – correlated with the nature of classroom instruction, and specifically the focus on scientific consensus (Plutzer & Hannah, 2018). A more explicit investigation along party lines found similar results: self-identified Democrats, when compared to self-identified Republicans, had a greater understanding of the greenhouse effect, a greater awareness of their state's science standards, and a reduced likelihood of delivering mixed messages to their students (Khalidi & Ramsey, 2021). Taken together, these results indicate that both viewpoint and group identity greatly influence teachers' understandings and dissemination of climate science. As such, students privy to differential climate change instruction simply as a function of their teacher's background may reinforce polarization within the United States. In other words, if ideological difference is enough to tip the scale towards climate skepticism, then youth coming to understand climate

change through the lens of their teacher's viewpoint could deepen regional divides as they become active adult citizens.

Given this intense polarization present in the United States today, it is no surprise that education has not escaped the grasp of partisan crusades. From evolution to Critical Race Theory (CRT), classroom curricula have increasingly become a part of the culture war constituting the conservative-liberal schism (Sawchuk, 2021). Pushback against teachers – from parents, administrative and governmental bodies, and communities – have impeded progress in widely installing K-12 CCE nationwide (Melia, 2019). Resistance is particularly strong among legislators. From a Connecticut representative who wants to remove climate change from statewide education standards, to an Oklahoma state senator who wants to grant teachers freedom to discuss "alternative viewpoints", to a Virginia lawmaker worried about climate change "indoctrination" – across the country, it seems government officials are attempting to mollify the far-right fringes with a stance against CCE (Melia, 2019). Indeed, some scholars even contend that the current anti-CRT campaign sweeping the country will set CCE further back, namely because it impedes teachers' ability to discuss environmental justice. The North American Association for Environmental Education's 2019 *"30 Under 30"* awardee, Kimi Waite (2021) argues that

> Those who attack the teaching of systemic racism want to deny students an understanding of history and an understanding of their lived realities in order to uphold systems of oppression and maintain the status quo for political gain. But teaching the links between racial justice and climate justice is one of the most powerful tools we have to educate the next generation of great thinkers, civic actors, and innovators who will develop climate change mitigation and adaptation solutions. Our future literally depends on teaching them the truth.

As Waite suggests, climate change cannot be reduced to degrees Celsius or metric tons of carbon dioxide in the atmosphere – it must be studied holistically in relation to the socioeconomic, cultural, messy world in which we all live (Waite, 2021). This entanglement of CCE and CRT reflects the ways in which climate change pervades society and even educational institutions, again highlighting the apparent difficulties in implementing a rigorous CCE approach.

However, despite the immense meddling from the bureaucracy, pushback from parents and communities may be exaggerated in public dialogue (current statistics vary in this regard, and more research is needed to conclusively determine how much resistance exists). Overt pressure to not teach climate change has been self-reported by as little as 4.4% (Plutzer et al., 2016) or 15% of teachers (Wise, 2010). But a more recent survey demonstrated that as many as a third of educators "worry about parent complaints" (NPR/Ipsos, 2019), suggesting that familial pushback, or at least *perception* of familial pushback, is on the rise. Still, amidst the chaotic social and political state, teachers are caught in a maelstrom of competing interests and changing expectations. This turmoil undoubtedly would impact educators' ability to teach climate science, even if they were highly motivated to do so.

The imperative for teacher activism

So then, what exactly ought teachers to do if they are caught in a push-and-pull between various stakeholders in the matter of CCE? Rather than try to extricate themselves from the political moray, here I argue that teachers *should* be, in a sense, activists: taking a firm stance on climate change, instilling in students a holistic environmental literacy, and preparing the next generation for their own climate-centric activism.

Prominent scholar Bree Picower defines teacher activists as educators who strive towards social justice both inside and outside of their classrooms (Picower, 2012). However, the pervading cultural narrative is that education can and should be "neutral," a view commonly held among teachers themselves (McGregor & Christie, 2021). As exemplified in the numerous examples of political influence on CCE, the field of education – like climate change – is inherently entangled in social justice and reciprocally relates to issues of oppression, equity, power, and access. Picower (2012) calls on all educators to engage with these issues, both in pedagogy and in extracurricular behavior, as a strategy for social change and for combatting injustice. While activism outside of the classroom is largely outside the scope of this paper, it should be considered a valuable potential next step for teachers already working within their classrooms to address CCE. Even inside the classroom though, Picower writes that every teacher's role is to "contribute to the broader political project of identifying and eliminating oppression in order to work toward a more democratic society" (p. 4). Wading through the politicized educational system that masquerades as an unbiased institution, educators need to address students' and communities' concerns with the constructs perpetuating injustice like racism, ableism, homophobia, classism, and capitalism, among others.

So, if climate change is a social justice issue, and assuming that teachers have an obligation to engage with social justice activism, it naturally follows that climate change activism is well within the prerogative of all educators. Indeed, Picower's notion of teachers establishing "a more just society" (Picower, 2012, p. 4) closely aligns with many environmental activists' goal of a major social change weeding out the roots of climate change and creating a "just transition": a better world than the one that created climate change in the first place (Velicu

& Barca, 2020). Framing climate change education in terms of social justice pedagogy evokes – and is necessary for – the third tier of CCE, the only one of the three to readily "re-orient toward broader action against the mainstream status quo" (Drewes et al., 2020, p. 78). Furthermore, Picower's particular emphasis on activism for education reform itself coalesces with an activist pedagogy for CCE: "education itself cannot be reformed as if it exists in a vacuum – it is part and parcel of any authentic effort to bring about the social change required by climate justice" (McGregor & Christie, 2021, p. 661). It is one and the same societal reimagining that is necessary for both liberatory education and an end to climate change, again emphasizing the intricate web of interrelated issues at hand.

CCE activism in practice

Increasingly, teachers and pre-service teachers have learned about the reproduction of inequalities related to race, class, and gender in schools, resulting in a modest surge in educator activism (Lowenstein et al., 2010). Climate activism among educators, on the other hand, appears to be a sparser occurrence. The dearth in such activism probably arises for the very same underlying reasons that CCE has yet to become ubiquitous and effective: teacher deficits in knowledge and confidence, social controversy, and logistical constraints. Still, there exist powerful examples of organizations and educators skillfully integrating climate and environmental activism into their classrooms and their lives.

The relatively new organization known as ClimeTime provides one apt example of this integration. ClimeTime is a Washington based collaboration between state education agencies, community groups, and the University of Washington that works to systematically improve climate science education (Lohr & Haroutunian, 2021). ClimeTime mainly approaches this goal via creating and implementing educator professional development (PD) opportunities. Since

2017, thousands of Washington teachers have participated in PD run by ClimeTime – itself an initiative funded by the state government – and even more have undoubtedly engaged with the initiative's materials which are published as freely accessible "open educational resources" online (ClimeTime Project Portrait, 2020). Inspired in part by the upswell of youth climate activism around the world, ClimeTime has more recently launched a "Climate Justice League" (CJL) to "recognize and address the deep interconnections between science and social justice" (ClimeTime Project Portrait, 2020). A 2019 inaugural cohort of fourteen teachers met and shared in learning about climate and environmental justice with the goal of incorporating gained knowledge into their middle-school and high-school science classrooms. The group met with activists involved in climate justice, explored existing curricular resources, and developed classroom learning activities that were appropriate for their own students and school context (ClimeTime Project Portrait, 2020). Indeed, 2020 saw the embarkment of two more teacher cohorts on their own CJL journeys, further cementing climate justice as an integral aspect of ClimeTime's mission. Notably, the CJL initiative worked from a framework of best practices that teachers could ostensibly use as they engaged their own students with climate justice. Centering teachers' personal experiences, supporting the complex emotions that may arise when learning about climate change, cultivating collective empowerment and local partnerships, and sparking action – these tactics not only enabled teachers to better learn about climate change but also modeled effective and relevant methods to bring back to K-12 classrooms (ClimeTime Project Portrait, 2020).

Bill Bigelow provides another example of an educator-activist amalgam. Bigelow, now editor of *Rethinking Schools* magazine and Co-Director of the Zinn Education Project, spent his

decades-long tenure as a social studies teacher challenging the dominant paradigm of how history is taught "while teaching more honestly about the historic realities that shape the United States" (Shetterly, 2020). But Bigelow's work did not stop at history class. Working towards environmental justice both in and the classroom, in 2011 Bigelow lobbied Scholastic Publishing to stop circulating an American Coal Foundation pamphlet to elementary school teachers and children. Although national standards "stipulate that students should learn about the advantages and disadvantages of different types of energy sources", the pamphlet in question was unquestionably and uniformly pro-coal, and Bigelow could not find evidence of Scholastic disseminating any other materials to the contrary (Laufe, 2011). In just two days of incredibly concerted efforts – involving, in part, thousands of emails and a New York Times article –Scholastic agreed to permanently cease distributing the pamphlet, a dramatic success for Bigelow and the climate justice movement.

Currently, and in a similar vein as ClimeTime, Bigelow has spearheaded the "Teach Climate Justice Campaign" as part of his work as Co-Director of the Zinn Education Project, an organization with the mission of introducing students to "a more accurate, complex, and engaging understanding of history than is found in traditional textbooks and curricula" (retrieved from the Zinn Education Project website on November 10th, 2021). The Teach Climate Justice Campaign has a tripartite aim: create an online library of freely accessible climate justice curricular materials, host workshops and dialogues for teachers to learn about and reflect on climate change education and promote the urgency of climate justice education across the nation (Bigelow, 2019a). Evoking youth climate activist Greta Thunberg, Bigelow writes in the

Spring 2019 edition of *Rethinking Schools,* "Our house is on fire. No matter what we teach, this work belongs to all of us".

Scaling out to a more systematic approach, the school district of Portland, Oregon has embraced a comprehensive climate literacy and justice curriculum, arguably the most forthright endeavor of its kind in any school district nationwide. A unanimous school board decision followed a tireless effort from teachers, students, parents and other activists (including Bill Bigelow), calling on the district to implement a social-justice oriented climate curriculum and abandon textbooks that attributed modern climate change to natural causes. The Portland Public School system (PPS) now has an on-the-books mission to "develop transdisciplinary curriculum…that empowers educators and youth to become transformative racial equity leaders and global stewards" and "to empower youth to lead the district and the world in becoming more sustainable" (retrieved from PPS website on November 10th, 2021). Although too often school districts impose new curricular initiatives on teachers without their input, this example of educational activism notably operated at the grassroots level. Leadership from those who would be most impacted by the outcomes – students and teachers – played an integral role in determining the terms of the movement's demands. Furthermore, backed by external activist groups like the Sierra Club and the Climate Action Coalition, the final resolution submitted to the school board insisted on *continued, student-led activism* in response to the climate crisis:

> All Portland Public School students should develop confidence and passion when it comes to making a positive difference in society, and come to see themselves as activists and leaders for social and environmental justice…; and it is vital that students reflect on local impacts of the climate crisis, and recognize how their own communities and lives are implicated (Portland Public Schools Board of Education, 2016).

Indeed, in the week prior to the resolution's submission to the board, a subset of the CCE student and teacher activists traveled to a demonstration protesting several oil refineries in Washington (Bigelow, 2019b). Clearly, even before the school board's decision to adopt the resolution, there existed an eagerness and capability to engage in climate activism; instilling a codified approach throughout PPS could only further these activist aspirations among more students and educators alike.

In its undertaking of such an ambitious and expansive framework, PPS evokes the most transformative tier of CCE. It is thus no surprise, given the almost unprecedented nature of PPS's mandate, that there was immediate and intense backlash. Latching onto the "ban" on climate change denying materials, a conservative media vitriol ensued, with PPS accused of indoctrination and censorship (Dicker, 2016). Still, PPS and its new Climate Justice Committee forged ahead in the following months, incorporating the work of Marshallese activist Kathy Jetñil-Kijiner, introducing new climate-centered courses into high schools, and conducting a thorough vetting of science textbooks for problematic climate portrayals; their works continues today (Bigelow, 2019b). Although this vignette again highlights the deep controversy surrounding CCE, it also speaks to the success of collective and multigenerational efforts to create change. Trite though it may sound, it proves true that when students and teachers work together, they can transcend old paradigms and forge the way for the future of education and society.

Best practices for teaching about climate change

Fortunately, there are already promising curricula in place in select locations around the country which provide a glimpse at best practices surrounding CCE. In one extensive review of the existing literature, Monroe et al. (2017) found that many aspects of successful CCE have

already been identified as important aspects of any educational setting, including making climate change information personally relevant and meaningful, and designing activities to engage learners.

In terms of relevance, climate change communicators for all ages indicate that capturing the "distant, global, nebulous threat" of climate change in a way that is personally and oftentimes locally salient (Monroe et al., 2017, p. 799). In one localized curriculum, middle school students in Colorado met with scientists at a nearby climate laboratory, simultaneously exploring data collection methods and climate science in a familiar context (Hallar et al., 2011). Some studies have shown that place-based interventions appear to improve student outcomes, at least in terms of knowledge gains. Students in the San Francisco Bay Area, CA were most likely to identify adaptation strategies related to personally relevant climate risks, like sea level rise that might affect their low-altitude location (Bofferding & Kloser, 2015). In climate change, just like in many educational spheres, one can see the importance for learners to relate to and become invested in the material.

Engagement is also important to sustain that investment. Student-centered and inquiry-based approaches such as debates, hands-on laboratory activities, and field trips undoubtedly capture student interest far more than worksheets and rote presentations. Indeed, Karpudewan et al. (2015) empirically showed as much. In their Malaysian study some students were randomly assigned to an experimental curriculum group operating on a constructivist approach, which used engaging activities like a role play integrating the science and politics of the greenhouse gas effect. Other students were assigned to a control group that covered the same topics as the experimental group but did it in a traditional teacher-centered lecture format. At the

end of the 5-week curricular unit, students in the experimental group had significantly improved understanding and significantly fewer misconceptions related to climate change, a result most probably attributed to the engagement factor in the experimental group (Karpudewan et al., 2015. The authors speculate that the varying suggestions and ideas that emerged during student-led small group discussions allowed students to analyze their existing knowledge, generate new questions, and gain exposure to multiple perspectives on a given issue (Karpudewan et al., 2015). Although not explicitly addressed in Karpudewan et al. (2015), other studies point to the role of engagement in inspiring *action* as well as knowledge gains. For instance, Svihla & Linn (2012) found that a structured student investigation helped middle schoolers integrate their climate knowledge gains and make decisions regarding future energy use. Engagement and personal relevance are well-researched pedagogical tools enhancing education in a variety of contexts. However, it is also important to employ strategies to address the common barriers unique to climate change, many of which are explained in the above sections.

Monroe et al. (2017) identified four themes specific to successful climate instruction. First, deliberative discussion helps learners understand others' viewpoints and knowledge about climate change, which, in turn, deepens their understanding of their own viewpoint and knowledge (Monroe et al., 2017; Klosterman & Sadler, 2010). In their study on CCE in a 5th-grade classroom, Mason & Santi (1998) suggest that "argumentative practice, stimulated in group discussions, allows students to transform their personal beliefs into reasoned views" (p. 82). Second, interaction with scientists and the scientific process inspire student interest in STEM fields and enhance learning outcomes (Monroe et al., 2017; Bush et al., 2016). Additionally, incorporating laboratory techniques and other scientific practices aligns with many

NGSS goals such as "asking questions and defining problems", "analyzing and interpreting data", and "planning and carrying out investigations" (NGSS Lead States, 2013). Third, programs that *specifically* and *intentionally* addressed common misconceptions were most effective at dispelling them (Monroe et al., 2017; Karpudewan et al., 2015). Fourth and finally, school and community focused projects allowed students and teachers to consolidate and put their knowledge into practice (Monroe et al., 2017). Such actions could possibly lead to a sustained role in climate activism that would be necessary for a societal overhaul of climate change. So, good interventions exist. But how do teachers themselves learn about and put these interventions into practice?

Professional development related to CCE

Altogether, there is a clear need for professional development (PD) related to CCE. Teachers, as highlighted in prior sections, are lacking in the knowledge and confidence necessary to teach about climate change effectively and from a social justice perspective; PD opportunities provide some of the best ways for teachers to address such shortcomings and alter their classroom practice. However, a shortage of climate change related programs hinders progress in this area (Shea et al., 2016), despite the fact that two thirds of U.S. earth science teachers surveyed in Plutzer et al.'s (2016) study expressed interest in PD focused entirely on climate change. Not only a need but a *desire* for CCE PD remains an unfulfilled vanguard.

But just any PD will not suffice. Quality science PD has been found to rely on three general attributes: specificity to content knowledge, proximity to practice, and contextual considerations(Luft & Hewson, 2014). A focus on science content is clearly needed to address teachers' common misconceptions so that teachers, in turn, can bolster students' climate literacy. Emphasizing proximity to practice facilitates a more felicitous translation to classroom

pedagogy: because teachers "engage in PD in ways that cohere with their own experiences, the norms and expectations of their school, and in conversation with curricular concepts" (Shea et al., 2016, p. 70), modeling effective tools to teach about climate change is a must for any successful CCE PD.

Zooming out, effective PD also needs to account for the political and social context surrounding teachers' decisions. This last factor is especially important for issues as culturally controversial as climate change; teachers who consider PD to be more aligned with the overall social context of their school are more likely to transfer their knowledge gains into practice (Penuel et al., 2007). Although many teachers report favorable appraisals of socioscientific issues, research suggests that K-12 science educators struggle to assimilate an SSI-focused pedagogy into their classrooms, and those who can tend to do so "infrequently and superficially" (Foulk et al., 2020, p. 2). Encouragingly, Plutzer et al. (2020) found that the decades-long increase in teacher PD related to evolution, another highly controversial socioscientific issue, has caused an increase in evolution being taught in the classroom and a decrease in educators that endorse creationism.

For example, the very same practices that have been recommended for CCE PD proved successful in one intensive evolution PD program for pre-service teachers in New Jersey (Ha et al., 2015). Specifically the program's designers based their evolution PD on "a strong consent focus; active learning (student-centered inquiry-based activities); coherence (alignment with NJ State Standards and district goals); duration (the equivalent of one graduate class); and collective participation (collaborative learning in school-based context)" (Ha et al., 2015, p. 6). These tools resulted in increased knowledge gains and acceptance related to evolution that were present both

in the short-term and were maintained over time (Ha et al., 2015). Thus, as seen in this example, specific PD targeting how to teach about socioscientific issues is essential for successful climate change education.

The MADE CLEAR (Maryland and Delaware Climate Change Education Assessment and Research) program offers the promise of a systematic approach to aiding teachers in developing their CCE capabilities. The keystone facet of MADE CLEAR was their Climate Change Academy (CCA), a year-long tripartite program including a week-long residential summer institute, four online follow-up sessions to address linger climate change questions, and two in-person follow-up sessions to address pedagogical methodology for CCE (Shea et al., 2016). Notably, this program provides an apt example of effective PD because it addresses the three aforementioned best practices of CCE PD which are, again, specificity to content knowledge, proximity to practice, and contextual considerations.

In terms of content, the CCA extensively addressed climate change content related to the greenhouse gas effect, consequences of climate change, and mitigation and adaptation, with a heavy emphasis on causal human activities (Shea et al., 2016). Teachers participated in NGSS standards-based activities in collaboration with climate scientists, often completing inquiry-based experiments in an outdoor environment (Shea et al., 2016). Based on their newfound knowledge, teachers then designed instructional units for their given grade level and educational setting, thus connecting their experiences to practice. At the culmination of this experience, most teachers reported scientific learning gains – especially in regard to carbon cycling and sea level rise. Even more crucially, the overwhelming majority of participants developed increased familiarity with

pedagogical practices supported by NGSS standards (Shea et al., 2016), which include use of data modeling, technological resources, and inquiry-based learning (NGSS Lead States, 2013).

Still, general aspects of successful professional development may prove just as useful to take into account as specific considerations relating to CCE PD. One recent study investigated the thought processes of in-service teachers who did not attend an available climate change workshop (Ennes et al., 2021). The reported number one barrier to attendance was a lack of time for professional development, closely followed by a lack of time to teach the curriculum the PD was intended to address. Interestingly, this was equally true for teachers who did and did not feel confident about whether climate change was occurring (Ennes et al., 2021). This study suggests that climate change PD providers, rather than designing new climate change related strategies specifically, could pivot to mitigating common barriers to PD participation using research-based best practices (see for example, Darling-Hammond, 2017). Teachers are often overworked and underpaid, so building in paid time for teachers to participate in PD could be a ready solution to alleviating some of the costs (both literal and metaphorical) of engaging in CCE PD. No one solution will work for every teacher, so organizations may need to engage a varied range of strategies to recruit teachers involving administrative support, community buy-in, financial incentives, devoted time, and sociocultural considerations (Ennes et al., 2021). Regardless of the method, PD is one of the first steps in improving children's climate change education and more work is needed to make it a widespread reality.

To be clear, PD is a necessary *first* step; it is not and cannot be a panacea for remedying the barriers to and issues with CCE. PD must always be considered within the broader context of school, community, state mandates, and society. Just as effective climate pedagogy is holistic and

multifaceted, so too must the fight to instill widespread CCE integrate multiple avenues of attack. PD is but one piece of a larger puzzle that may include legislative lobbying (Bigelow, 2019) or invoking parental support (NPR/Ipsos, 2019).

Case study: One teacher's views on CCE

To illustrate many of the above points, this section will now turn to the findings of an interview with Amit Schwab, a teacher located in Pennsylvania. At the time of writing – in December 2021 – Mr. Schwab had been teaching for 5 years at Saul High School (SHS) in various capacities. SHS is a magnet high school in urban Philadelphia and the largest agricultural farm school in the United States (retrieved from SHS website on December 18th, 2021). The mission of SHS closely aligns with CCE teaching goals as it is to "promote student leadership that makes a difference in our world" through student application of "their knowledge and skills to address modern environmental and agricultural challenges" (retrieved from SHS website on December 18th, 2021). Mr. Schwab currently teaches tenth grade biology but has previously served as an environmental science teacher at SHS and the following opinions will reflect his multilayered position at the school over the years.

Mr. Schwab's overarching goal is "education for liberation", the building of skills that will allow his students to live freer lives and make more independent decisions. "Science practices and thinking skills are a really big part of that" according to Mr. Schwab, who feels that he "learned to think logically and reason logically" through his science education. Regarding content, Mr. Schwab wants to provide his students with the baseline knowledge they need to know in order to engage with the world around them and make educated choices. In fact, Mr. Schwab would rather students devote all of their biology education to ecology and genetics, two socioscientific issues with significant implications. Mr. Schwab suggests that "it's more

important for [students] to get the skills than a wide breadth of content…and when it comes to content, we are going to focus on two areas that students are going to be making big decisions about in their life whatever career they go into". Here, Mr. Schwab's thoughts echo that of many scholars who advocate for an interpolation of science, skill building, and social justice (Aikenhead, 1992; Rubba, 1991). As Science, Technology, and Society (STS) scholar Rubba (1991) says, "our best hope for the resolution of STS related issues is citizens literate in science and technology, and empowered to make informed decisions and take responsible action" (p. 303).

CCE in particular is important, according to Mr. Schwab, because "it already is and will continue to be a big part of [students'] lives". Furthermore, Mr. Schwab recognizes a need for "more diverse leadership in the environmental and climate movement". The SHS student body is 85% students of color, so Mr. Schwab notes that it is "particularly important" for his students to receive CCE and gain the background knowledge necessary to be scientifically literate citizens and potentially activists. Furthermore, given their place at a unique agricultural school, Mr. Schwab knows that his students are "well-positioned to become leaders in that world", referencing environmental justice movements with which he reports previous involvement.

Working at a progressive school like SHS, Mr. Schwab has taught climate change in a variety of contexts, including classes with names like "Contemporary Issues in Science" or "Science Proficiency Development". A big part of this education, again, is skill building involving online simulations, labs, and contemporary news sources that enabled students to engage with climate data. Working at an agricultural school and now teaching biology in particular, Mr. Schwab focuses more on the biological science content students will need to

navigate their other classes with an informed perspective on climate change; he knows that students will be receiving more of a socioscientific framework in other classes. As evinced in numerous studies, a teacher's specific context plays a big role in how they teach about climate change (Plutzer et al., 2016; Plutzer & Hannah, 2018; Khalidi & Ramsey, 2021). For Mr. Schwab, refocusing on the "nitty gritty" of climate science was most beneficial to students because they were already dealing with "big picture" ideas in their other courses. Indeed, some students actually have environmental science as their major and are receiving extensive climate change instruction. SHS thus deviates from most public high schools in its explicit and intense dive into CCE, potentially serving as a model for future education methodology.

Given this progressive specialty, Mr. Schwab experiences a lot of CCE support from teachers and administration, support less often found in many other school settings and for many other controversial issues (Picower, 2011). Illustratively, Mr. Schwab recounts hearing an English teacher in a nearby classroom play an audiobook of *Parable of the Sower* by Octavia Butler, an apocalyptic science-fiction novel known for its commentary on climate change and social inequality. In this English-class unit on "climate catastrophe" students were ultimately asked to present proposals for an outdoor learning space that could adapt to the challenges of a changing climate. Here, one can see the integration of climate science throughout various subject areas, including the humanities, as was seen in the aforementioned example of the Lowell School (Siegner & Stapert, 2020).

Interestingly, when Mr. Schwab has tried to partner with climate-oriented organizations during his environmental justice units, he reports a high degree of unreliability which is simply not compatible with "dealing with teenagers in a highly structured educational system". Mr.

Schwab justifiably laments that he cannot completely rework his curriculum, nor is it fair to his students to do so, just to accommodate the schedule of one person who cancels at the last minute or forgets the arrangement (occurrences that have happened often). Even when he does manage to get an organizer or activist in the classroom, the speaker is usually ill-prepared to engage with the students and a great deal of scaffolding is required on Mr. Schwab's part in order to make the event successful. It is important to note here, as exemplified by this account, that partnerships are not always appropriate. Even though scholars often point to the crucial role of working with "real-world" scientists or activists, "real-world" people may not have the experience necessary to translate their work to students. Ideally, students should be exposed to life outside the classroom, but it is important to remember the limitations associated with such a goal.

In reflecting on the social justice side of CCE, Mr. Schwab is a big proponent of "teaching *for* social justice instead of *about* social justice" (emphasis mine). For him, this looks like dedicating his time to his profession and helping prepare his students as climate literate citizens and leaders. He doesn't necessarily feel that he should be deeply involved in an on-the-ground organization because his work is with his students. In essence, Mr. Schwab believes that activism is different for different people, and should be based on what their particular skill set is.

Echoing aforementioned studies on professional development, Mr. Schwab also expresses a desire for PD to be more readily available and compensated. In one scenario, Mr. Schwab was invited to do a climate-oriented PD fellowship offered by the School District of Philadelphia. But when he ran the math on "what you were paid versus what you were expected to do", it wasn't the best use of his time and he understandably turned down the opportunity. Mr. Schwab

comments that “a way to support teachers is making sure that professional development and fellowship opportunities are providing significant compensation, and that the expectations for what teachers are doing are fulfilling and reasonable on top of having a whole full-time job” (and he notes that teachers are usually “working at least 10 hours more a week than what they are paid for” already).

When asked about the positive aspects of CCE Mr. Schwab recounted one successful event in which students worked with an electric company and conducted an energy audit of their school, thus applying their knowledge to action. Mr. Schwab notes that instances like these are the most rewarding parts of CCE, when he gets to see his “students learning skills that [he knows] will allow them to be independent thinkers and have more agency in the world”.

Conclusion

In sum, climate change education is a necessary and promising tactic to engender radical societal transformation. Such reimaginings of how we conduct our work, play, and lives are necessary to mitigate climate change and inhibit future environmental calamities by stopping them at their roots. Successful and powerful CCE incorporates a holistic perspective integrated across curricular subjects that comes from a social justice framework: students should be instilled with accurate scientific facts without sacrificing their ability to explore socioscientific ideas and come to generate their own knowledge base. Because this is clearly no easy feat, a first helpful step towards widespread and powerful CCE is professional development for both pre-service and in-service educators that is readily accessible, compensated, and contextually driven. While climate change education will not be the end-all-be-all of solving the climate crisis, empowering youth with the knowledge and skills to tackle the future is essential now.

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