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Science education in the Anthropocene: the aesthetics of climate change education in an epoch of uncertainty

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We have a responsibility as science educators to work with young people to enact education that enables collective rebalancing of relationships between humans and more-than-humans that are disturbed by human-induced climate change. However, to date, climate change education has not been prioritized in school science at a policy, curricula, classroom and community level, due to an aesthetic which does not sufficiently value climate science or recognize the social impacts of science as part of the discipline. We argue in this conceptual research paper from a pragmatist perspective that an aesthetic shift is required to include science as part of climate change education as a transdisciplinary endeavor that focuses on addressing socio-ecological challenges through student agency and community action. We explore the synergy between science education aesthetics and climate change aesthetics as we advocate for a transformative *aesthetics of climate change education*. We do so through a process of reflection on and conceptualization of our stories of climate change education in Australia. We propose that such an aesthetic (how we ought to value) should not be considered in isolation but rather that it forms the basis for the ethics (how we ought to conduct ourselves) and logic (how we ought to think) of young people being with us in a *community of inquiry in the Anthropocene*. We argue that we (teachers and students) ought to conduct ourselves in loving ways toward human and more-than-human kin that necessitates that we think as a community of inquiry to address the challenges of the Anthropocene. In doing so we suggest that we can realize a radical pragmatist meliorism for climate change education that is underpinned by the three normative sciences, the most foundational of which is aesthetics.

KEYWORDS

climate change education, science education, anthropocene, aesthetics, school strike for climate

Educational hope in an epoch of uncertainty – reimagining science education

We are all currently living in the Anthropocene (Lewis and Maslin, 2015), a geological epoch characterized by catastrophic human-induced climate change. Humans as well as more-than-human kin are on a path toward annihilation (IPCC, 2021). Human-induced climate change impacts marginalized communities with the least power and who have done the least to contribute to the current crises, such as young people with whom we enact education in both formal and informal contexts. Greta Thunberg famously exclaimed on January 25, 2019 at the

World Economic Forum in Davos, Switzerland, “Our house is on fire. I am here to say, our house is on fire.” While the situation is seemingly little different almost five years later, there is an increasingly bright glimmer of educational hope that has grown from this activism of Thunberg and the Youth for Sustainability/School Strike 4 Climate allies. As Ross (2020, p. 474) points out, the climate crisis is “firstly and above all a matter of the future of education,” with Toscano and Quay (2022, p. 1) making clear that at present “an ecological crisis coincides with an educational crisis.” The discipline of science, and by extension science education, is Janus-faced in this regard as it has instigated and exacerbated climate breakdown but may also play important roles in technological solutions, mitigations and adaptations, therefore providing more hopeful futures.

In a recent special issue of the *Australian Journal of Environmental Education* on the School Strike 4 Climate movement (Volume 38, Issue 1), we co-wrote a paper (White et al., 2022) with two school-aged members of *School Strike 4 Climate Australia*: Niamh O’Connor Smith and Harriet O’Shea Carre. We argue that humanity needs to “dare to think differently about education” (White et al., 2022, p. 27), as necessitated by young people’s initiation and continual enactment of striking from school as political climate action. We suggest this education/activism is an iterative and emergent process of “empowering young people through education to develop the skills and knowledge necessary for them to take action on matters of importance as we negotiate uncertain futures” (White et al., 2022, p. 37). In this regard, science education has a particular role to play as discipline-specific knowledges and practices that “enables them [young people] to take necessary action to generate change” (White et al., 2022, p. 36). Many young people value knowing and enacting climate science as part of their climate activism; science education ought to be about providing young people with the support and opportunities to realize what matters to them and to act accordingly so that science changes their lives and the lives of their communities in meaningful ways. All of which is a matter of aesthetics, and all of which is thus not possible without a carefully framed understanding and enactment of the aesthetics of science education (Wickman, 2006).

However, as we suggest in White and Ferguson (2021), realizing this education with young people requires us to critique and reimagine fundamental aspects of what education ought to be, which is difficult and risky work. We take up this challenge with this conceptual research paper forming part of our radical reimagining for the future of science education. We reflect on and conceptualize in new ways our stories of climate change education in Australia to realize a transformative aesthetics of climate change education.

Esthetics of science education

The intertwining of science education and young people’s climate activism is a matter of aesthetics, both *aesthetics of science education* and *aesthetics of climate change*. The history of philosophy and education is rich with a diverse range of accounts of what is meant by aesthetics. In this paper, we limit ourselves to one such account, albeit a highly respected and much-used account in science education (Wickman, 2006), which is Dewey’s pragmatist perspective (Dewey, 1934/1987). However, we also innovatively draw on Peirce’s pragmatist semiotic account of aesthetics (Peirce, 1894/1998, 1907/1998), in its relations with ethics and logic (Peirce, 1903/1998), to enrich Dewey’s

ideas as we strive to realize a new *aesthetics of climate change education*. In doing so, we continue to follow Sinclair (2006, 2007) in our endeavor to explore the productive synergies between Dewey’s and Peirce’s accounts of aesthetics (Ferguson et al., 2022; Prain et al., 2022), and what this might mean for teaching and learning science through/as inquiry (Wickman et al., 2022). We also, when needed, make use of Bourdieu’s (1984) notion of taste to make clearer the social nature of aesthetics in education, in particular for the discipline of science (Lima Junior et al., 2022).

A socio-semiotic pragmatist account of aesthetics

Dewey’s (1934/1987) account of aesthetics focuses on the way by which we make meaning of the world is determined by what we value as reflected in our judgments of objects and our associated feelings. We judge objects – that is the constituents of reality – as valuable (or not) in terms of whether (or the degree to which) they serve the immediate purpose as part of consummating experience. These judgments manifest not only cognitively but also emotionally as we experience either positive or negative feelings, which is dependent on whether (or not) the object is judged as moving meaning making closer to (positive, e.g., joy) or further away (negative, e.g., disgust) from the consummation of experience. As such, for Dewey, all feelings, and not just positive feelings, are potentially aesthetic in nature as paired with associated cognitions. Dewey also highlights the way in which meaning making through/as aesthetic judgments and associated feelings is always continuous in the sense that what is experienced in one sphere (e.g., school science) is intimately linked with the experiences in other spheres (e.g., home environment) as different objects are brought into alignment as we strive to know the world. This pragmatist account of aesthetics, not just Dewey but also Peirce whom we’ll hear more about later, also dictates that we develop particular sets of judgments and feelings that we are predisposed to enact in particular situations, such that we can talk of aesthetic habits (i.e., habits of aesthetics). Such habits are not routines that we execute in a robotic manner, but rather are beliefs as actions that we are aware of and which we can alter to change our meaning making practices. Bourdieu (1984) framed these habits of judging and feeling as taste, and argued that they are significantly shaped by our social and cultural milieus. As such, we certainly do not have complete control over our aesthetic habits because context – in the past, present, and future – always plays a key role, and often we are powerless as individuals to remove ourselves from certain contexts and/or immerse ourselves in other contexts. However, this is not to say that we cannot develop different or particular tastes, but to do so requires awareness, discipline and control in regard to what we think and feel. Aesthetic judgments and feelings are always dependent on context.

If we accept Dewey’s aesthetic perspective then there are certain objects, in relation to any particular purpose, that we ought to positively value as contributing to the consummation of experience and which should be included in the meaning making process. In contrast, there must also be certain objects that we ought to negatively value and so should exclude from the meaning making process as they do not contribute to the consummation of experience. As such, to advance meaning making in any particular sphere then we need to value specific objects in particular ways, and so we should feel and

think in certain ways. Therefore, aesthetics is normative in nature, as we will explore later through a Peircean lens, such that we ought to develop particular aesthetic habits/tastes to successfully undertake meaning making in different contexts, as we strive to consummate experience across different spheres.

Peirce (1894/1998, 1903/1998, 1907/1998) introduces a semiotic element to framing aesthetics that highlights the epistemic nature of cognitions and feelings. We call this “an emotionally-infused semiotic” or “a semiotically-infused aesthetic” (Ferguson et al., 2022, p. 771). In doing so, we follow the lead of Lemke (2015, p. 602) in considering that “feeling and meaning are coeval, coevolved, functionally complementary, co-determined, and co-determinative” in their development of/as systems of signs. Peirce proposes that meaning plays out through the triadic relationship between *object*, *representamen* and *interpretant* (all three combine to form the sign), with not only cognitions but also feelings manifesting in sign form. Such a Peircean account of semiotics is epistemologically and ontologically different in significant ways from representationism/representationalism (Lycan, 2023) according to which signs merely represent things in the world.

In coming to understand an object as part of consummating experience in our endeavors to realize a particular purpose to resolve a current situation, we engage with/generate cognitions and feelings as signs. These representamens stand for these objects as we experience the effect of the object-representamen connection as interpretants that themselves function as representamens/objects/interpretants in the ongoing linking of meaning-making triads known as semiosis. Therefore, developing particular aesthetic habits as specific tastes is a matter of sign making and transducing across/between different sign forms (e.g., cognitive and affective). It's critical to emphasize here that to consider feelings as signs is not to reduce feelings to cognitions, and to also highlight that feelings are at least partly manifested in corporeal and materials forms (so we could talk of embodied-material-semiotics). We thus reiterate that “conceptualizing feelings as interpretable meaning-filled signs” (Prain et al., 2022, p. 739) is of methodological as well metaphysical significance as it empowers us to explore aesthetics as a semiotic, as well as pragmatist and social, process.

Science disciplinary aesthetics

So, what does this socio-semiotic pragmatist approach to aesthetics mean in the realm of education? Östman and Wickman (2014, p. 378) argue that teaching and learning is “not about the transformation of an individual's cognitive structure” but rather “the transformation of observable habits in action.” And, as we have just explored, these habits necessarily include particular judgments and feelings as key to meaning making, so that education is about the development of aesthetic habits; or as Lima Junior et al. (2022) propose, teaching and learning is a matter of developing particular tastes. The role of teachers is to foster the development of such habits/tastes in students, while they themselves need to develop particular habits/tastes to make this happen for their students.

Wickman (2006) argues that students' and teachers' experiences of science are aesthetic in nature and in ways that are specific to the discipline, such that we can talk of “a science of disciplinary aesthetics” (Wickman et al., 2022, p. 727). Wickman (2006) expands on this

position to propose that this aesthetic manifests in two distinct, but related, forms; disciplinary and experiential. Disciplinary aesthetics can be understood as “appreciating the beauty of the objects of scientific study, as well as the elegance of scientific methods and accounts of these objects” (Hannigan et al., 2022, p. 798). As such, science is defined by “a taste for particular topics, inquiry approaches, and ways of thinking in this discipline” (Hannigan et al., 2022, p. 798). Experiential aesthetics involves “participants' feelings in engaging with the purposes, objects, instruments and inquiry strategies of a subject” (Hannigan et al., 2022, p. 798). The latter is considered to enable the former; “what students feel in doing science leads to their general taste (or not) for this subject” (Hannigan et al., 2022, p. 798). Disciplinary aesthetics for the learner and teacher thus consists of both personal feelings and meanings as well as disciplinary feelings and meanings.

Students' induction into the practices of science therefore involves an alignment between the aesthetics of science as a discipline and the aesthetics of students' encounters with the world, which includes science (Anderhag et al., 2015a,b). The role of the teacher is to provide opportunities for students to develop a set of habitual judgments that value the various objects of science to enable understanding of natural phenomena as manifested in the objects of reality (Anderhag et al., 2015c, 2016). As we argued earlier, these value judgments are cognitive and emotional in nature as students start to, for example, “like” and “dislike” certain science objects in terms of their facilitating the consummation of scientific experience as they are, for example, “happy” or “disgusted”. This development of a taste for science is a semiotic process as students' cognitions and emotions, as well as the objects of focus, are present as signs of various forms that must be recognized as such both in their use and creation.

We do not have scope in this paper to systematically detail all the objects that are included (and by extension those that are excluded) from science, but we can generalize and say that the objects valued in science are those which progress cause-effect understandings of the structure and function of natural phenomena. It is such objects that we want students to value and thus to think and feel positively about as they do science as a semiotic undertaking (i.e., meaning making as/through signs). But this is only possible if the students' personal aesthetic experiences are aligned with those of the discipline of science, in other words indoctrinating students with a disciplinary aesthetic of science is antithetical to the aesthetic endeavor. The development of taste, including when it comes to science, is a lifelong endeavor that is always socially constituted across and between multiple life words of the individual (Tytler and Ferguson, 2023).

While disciplinary boundaries evidently serve an important role in maintaining the aesthetic integrity of particular disciplines, including science, this does not preclude the integration of different disciplines as part of rich learning experiences for students (Prain et al., 2022; Wickman et al., 2022). An important part of preparing students for their future lives as agentic citizens who are able to productively negotiate the challenges of the Anthropocene, is authentically integrating science with other disciplines as part of project-based learning and other similar approaches. Teachers' and education researchers' success in fusing science with the arts (e.g., Caiman and Jakobson, 2022; Hannigan et al., 2022; Mun, 2022), to provide potentially transformative learning experiences for students, is a result of clearly determining and demarcating the distinctive tastes of science and the arts.

Esthetics of climate change (education)

Our concern in this paper is to develop a new aesthetic of climate change education, so we now turn from the aesthetics of science education (an aesthetic with a disciplinary and personal dimension) to the aesthetics of climate change (an aesthetic with multiple disciplinary dimensions and with a strong personal dimension). To be clear, what we advocate as an aesthetic of climate change education is not simply the combination of the science and climate change elements; it is something more and something different, as necessitated by the extreme nature of the educational and environmental challenges that we must negotiate in the Anthropocene. It's what [Mikkonen \(2022, p. 57\)](#) calls a "future aesthetics," concerning as it does "new models for appreciation that are able to account for environmental and conceptual changes." In making clear what is new and useful about our socio-semiotic pragmatist account, we will also map out (in a selective as opposed to exhaustive way) existing aesthetic accounts of climate change education, as we value the important work of our environmentally-oriented educator colleagues.

Environmental aesthetics in the Anthropocene

[Mikkonen and Lehtinen \(2022\)](#) argue that the extreme nature of the Anthropocene calls for an equally radical environmental aesthetic to account for our fundamentally altered experiences of the world. This is a world consisting of "mashed-up Anthropocene environments" ([Di Paola and Ciccarelli, 2022, p. 85](#)) consisting of "the dynamic entanglements and agglutinations of the human and non-human, local and planetary, fossil-fuelled, capital-driven, techno-powered, ecologically systemic forces and processes" ([Di Paola and Ciccarelli, 2022, p. 88](#)) that define the current epoch. As [Auer \(2019\)](#) points out in his overview of environmental aesthetics in the age of human-induced climate change:

Philosophical inquiries on aesthetic experience in the age of climate change are relatively few, though interest in the subject is likely to grow as climate change affects more people's associations with nature and with places and spaces people inhabit. ([Auer, 2019, p. 2](#))

We consider our paper and our work more generally to form part of this philosophical enlightening of the changing aesthetic nature of our experiences in the Anthropocene, which of course includes education in all its forms (both existing and potential). This is a world, according to [Auer \(2019\)](#), with:

(1) Fewer opportunities for positive environmental experiences and an overall increase in ugly environmental conditions; (2) increasing instances of climate change "winners" and "losers" and zero sum outcomes; and (3) the increasing obscurity of the moderate autonomist orientation, particularly as the consequences of climate change—and the ugliness it generates—intensifies. ([Auer, 2019, p. 7](#))

Environmental aesthetics, as outlined by [Auer \(2019\)](#), is concerned with engaging with these issues; the ways in which

we (humans) care about the natural environment in all its forms, which includes both cognitive and noncognitive (i.e., emotional) processes of initiation and response. Such caring is necessarily grounded in how we value this environment, with ongoing debate as to whether such aesthetics is necessarily linked to our moral concerns (i.e., how we conduct ourselves) ([Brady, 2022](#)). It is important to note here that there is a prominent thread running through the environmental aesthetics literature (referred to as the moderate autonomist perspective) which argues that such aesthetics need not entail issues of morality, something with which we strongly disagree as we will explore later. In this way, we support [Auer \(2019, p. 7\)](#) in foregrounding "the moral quandary of whether we should alter our climate-forcing behavior today, knowing that business as usual" is what got us into this mess in the first place. In a "climate change-ravaged world, aesthetic values are more difficult to isolate from moral consideration" ([Auer, 2019, p. 9](#)). We join [Brady \(2022, p. 41\)](#) in emphasizing the need for us to be attuned to "aesthetic-ethical harmonies and conflicts" when it comes to the current climate crisis and the role of science education.

As the world changes in radical ways due to human-induced climate change, will our positive and negative experiences of the biotic and abiotic environment also change in radical ways that make our lives less satisfying? Those invested in environmental aesthetics are deeply concerned with this question, and almost unanimously answer in the affirmative ([Mikkonen and Lehtinen, 2022](#)). While many of the challenges we currently face are global in nature – that's part of their "wickedness" – it is at the local scale that these value judgments about nature play out most meaningfully for us; the impacts of human-induced climate change are felt most intensely in our daily lives. It is in our daily routines (i.e., habits) that we intimately encounter but also find refuge from the impending doom of global forces; it is the alignment of daily aesthetics of caring for nature with the aesthetics of nature in its pan-ecological forms that makes us feel happiness or sadness ([Auer, 2019](#)). To be clear, this is not to reduce aesthetics to a bourgeois contemplative relationship with nature, rather aesthetics is a concern for all people (regardless of race, gender, class) in their valuing of what matters most to them which includes all the various political, social, and cultural entailments. Such is the inequity of human-induced climate change that those most likely to need to change their daily routines are those who have least contributed to the current climate crisis and who have the least power to change their current circumstances. However, the momentum of these climate change forces is so strong that no one is immune; all will have to adapt their daily practices in some way ([Brady, 2022](#)). It is not just that we will have potentially fewer positive aesthetic experiences of the biotic and abiotic environment, but all of our aesthetic experiences will take on a different form, as not only will routines "need to adjust, but more radically, people may need to prepare for a perpetual state of complex problem-solving" ([Auer, 2019, p. 7](#)).

The role of climate science is critical here for the "object of science-based aesthetics is ecological processes and ecosystems" ([Mikkonen, 2022, p. 51](#)). Climate science "helps contextualize conjectures about life in a climate-changed world, sharpening our understanding of who will be (and is already) affected by climate change, with implications for our understanding of aesthetic experience" ([Auer, 2019, p. 7](#)). In this way, environmental aesthetics is infused with science, such that our value judgments about nature in the throes of human-induced climate change are at least partially framed by the aesthetics of science

(Mikkonen, 2022). But we must be ever vigilant to the instrumentalist and Cartesian nature of this inherently Western science; as environmental aesthetics develops as a response to help us cope with our dramatically changed/changing world, those advocating for its merits (including us) seek to productively disrupt entrenched dichotomies in particular the divide between ‘human’ and ‘non-human’ (Diaconu, 2022). We need to realize that we (humans) are not separate from the natural world, but rather are part of it (and vice versa). In so doing we can realize that all within and beyond the human needs to be cared for through our value judgments, what Diaconu (2022, p. 71) refers to as “a transaesthetic.” This position is strongly aligned with what we argue later in this paper in regard to the merits of our pragmatist semiotic account of aesthetics for climate change education in the Anthropocene.

Esthetics + climate change + education

Auer (2019, p. 9) reasonably suggests that “one might imagine experts in climate change aesthetics helping people to adjust to the harsh realities of their transformed and disfigured environments.” The recent emergence of climate change education aesthetics, we argue, is part of this future-oriented initiative to take seriously our aesthetic experiences that necessarily involves the role of education as a way for young people to work with adults (and vice versa) in intergenerational learning to relate to this radically changed/changing world in satisfying ways. We share Van Poeck’s and Säfström’s (2022: 399) interest in the “the relation between education and societal transformation” in particular “the public role of education in the face of sustainability challenges through interdisciplinary research collaboration.” Teachers and students, which we must remember are mutually-constitutive roles with which both adults and young people identify, are “experts” in this sense presented by Auer (2019). They (which includes us) are constantly engaged in aesthetic work as education to realize new relationships of knowing and being (Todd, 2020). To date, much of this work to understand and make explicit the aesthetic dimension has focused on climate change education in its “informal” form (Hansson and Öhman, 2022), most notably the public pedagogies of young people striking for the planet (Verlie and Flynn, 2022). While recognizing the essential role of such informal educational experiences for young people, we propose in this paper the need to consider also the aesthetic dimension of climate change education in formal settings, most notably schools (this includes the various curricula and policies that structure the school experience for teachers and students), and in particular the role climate science can play in empowering young people to enact climate change education for caring futures for all.

The ongoing global actions of the Youth for Sustainability/School Strike 4 Climate movements have been the catalyst for this realization of the need to take seriously the aesthetics of climate change education. In August of 2018, Greta Thunberg protested outside the Swedish Riksdag in Stockholm and in doing so, along with fellow protestors around the world, she initiated a global youth movement which demands that we radically change our ways in order to realize a more just future for human and more-than-human. Young people are leaving formal educational settings (i.e., schools) and entering the streets (as informal educational settings) to realize this change. In the process, they are educating both themselves and others; these youth movements are educational as well as environmental movements. As Wildemeersch et al. (2022) argue:

Youth activism is a site where taken-for-granted ways of relating to each other and to the world are being questioned and where young people learn from their peers and from informed adults about what is currently at stake and, through their practices, learn how to deal with these challenges. (Wildemeersch et al., 2022, p. 421)

Wildemeersch et al. (2022) make clear that in order to understand, appreciate and contribute to this revolutionary movement that it is essential to recognize the aesthetic nature of what is taking place; the environmental, educational and aesthetic elements are intimately intertwined. They draw on Latour’s and Stark’s (1999) work and Latour’s later musings Latour (2018) to consider “new attachments to the Earth” (Wildemeersch et al., 2022, p. 421) as they seek to frame the aesthetic nature of these youth movements in relation to the environment and education. In doing so, they continue the Latourian work of Todd (2020, p. 1112) who argues for the need for education in the Anthropocene to focus on “encounters of the world” as opposed to “relations to world” in shifting toward ecocentrism. According to this approach, humans are attached to non-humans and vice versa, such that the traditional dichotomy between humans and non-humans is blurred as they are “interlinked and interdependent” in forming “specific alliances or bonds” (Wildemeersch et al., 2022, p. 422). In making clear the aesthetic repercussions of such a framing, Wildemeersch et al. (2022, p. 422) point out that “the choice is not between attachment and detachment, but between good and bad attachments, those attachments that contribute to sustainability in contrast with attachments that tend to decrease our capacity to live in a sustainable way.” The process of determining what is a “good” or “bad” attachment is all about value judgments and thus is a matter of aesthetics. Wildemeersch et al. (2022) highlight that aesthetics is not simply a cognitive process but also emotional, bodily and transactional (i.e., ongoing interchange between objects and subjects) in nature as grounded in our everyday experiences. As Todd (2020, p. 1110) points out, education ought to be “a way of creating encounters of the world that educate about the climate emergency while also giving time for climate sorrow” on the path to “a living relationship to the more-than-human world” (Todd, 2020, p. 1112).

Wildemeersch et al. (2022) propose that the aim of the Youth for Sustainability/School Strike 4 Climate movements is to realize “good” new attachments of humans to non-humans (and, presumably, humans to humans). As such, these revolutionary actions of young people are intended by them to educate themselves and others in the value judgments that will save the planet. While such endeavours and their entailed framings of education are issue-focused as opposed to focused on the particular and distinctive disciplines of knowing at play, Wildemeersch et al. (2022) point out that science and its links with aesthetics seems to be central to the educational potency of these movements. In this way, there is a recognized need to make explicit the aesthetic nature of the science component of climate change education and what this might mean for an aesthetics of climate change education, which is the aim of our paper.

The conspicuous absence of climate change education

Globally to date, climate change education has generally been excluded from school science, at a policy, curricula, as well as the

classroom level. There are some notable exceptions that we explicate below, yet these remain the exception not the norm in a global context.

The status quo

Climate science is noticeably absent from students' and teachers' experiences of science in the classroom. In our recent paper (White et al., 2022) with *School Strike 4 Climate Australia* members Niamh O'Connor Smith and Harriet O'Shea Carre, Harriet reflects on her formal school experiences of climate change education:

I was at a Steiner school, and I do not think we ever explicitly learned about anthropogenic climate change. However, a relationship with nature and conscious consumerism were strongly fostered. At school we were taught about ways to live more sustainably, we learned a lot about organic and biodynamic agriculture. We learned about climate change more so from a humanitarian perspective than a scientific one, but we were always encouraged to listen to the climate scientists. (White et al., 2022, p. 33)

So, for Harriet, climate change education to date has tended not to include a strong focus on climate science at school, rather the climate crisis is framed more so with a social science lens to inform sustainable living. But, importantly, Harriet does point out that as school students, they were supported to value climate science but only in a passive sense of forming an audience for the climate scientists.

Niamh tells a similar story:

I went through mainstream education, public school in Castlemaine and I learnt about climate change, but not at a deep level, other than it existed. Even doing Year 12 chemistry in 2020, you learn about fuels, both renewable and non-renewable, and that carbon dioxide is causing the enhanced greenhouse effect. But the course did not address the need to phase out the fossil fuels that cause the detrimental effects of human-induced climate change...Although I am a maths and science person, it wasn't until I got involved in the movement that I took a deeper dive into the science. I initiated learning the science myself and I was exposed to the science as part of the movement. (White et al., 2022, p. 33)

So, for Niamh, while she experienced climate science at a superficial level as part of climate change education at school, it was only through her participation in the *School Strike 4 Climate* movement that she developed a deep understanding of climate science and what it could do for her and her community in productively negotiating the climate crisis. In addition, Niamh points out that the epistemic power of this science to inform responses to the climate crisis was blunted as it was not connected with the social, economic, and cultural factors. These school stories of Harriet and Niamh indicate that climate science in the classroom is generally not included as part of climate change education in an integrated (and thus meaningful way) with other ways of knowing and being in the world. In other words, climate science in its full richness seems not to be valued as part of climate change education in the current school context.

As we know, what takes place in schools is strongly shaped by the curricula, and the situation is no different with climate science as part of climate change education. In their recent study, Dawson et al. (2022) show that across the compulsory middle-school years in six countries (Australia, Israel, Finland, Indonesia, Canada and England) that regarding science and geography:

(1) the term 'climate change' appears in the formal curriculum of all six countries in science or geography; (2) approaches to climate change in the curriculum differ substantially across different countries; (3) climate change is often presented as a context, example or elaboration for other science concepts rather than a discrete topic; (4) the presence of climate change in most curriculum documents is scattered and spread over multiple years and (5) knowledge about causes of climate change predominates over action and behavioral changes. (Dawson et al., 2022, p. 1,379).

As such, when it comes to science curricula, we propose that an aesthetic is operating that does not value climate science and social injustices as part of the science discipline, indeed there seem to be a plethora of value judgments that explicitly exclude climate change as a matter of concern. In addition, climate science as part of climate change education has historically been absent from policy and curricula documents that extends beyond local, regional, and national contexts to the international arena of testing and related education processes and protocols (OECD, 2009). Our message here is clear; the problematic state of climate science as part of climate change education (in our case in Australia) is a result of an aesthetic operating at policy level that trickles down to curricula and classrooms that values neither climate science as part of climate change education nor its entanglement with other disciplines. This is a disturbing situation as it denies young people the opportunities to develop an appreciation for climate science, how science can and should inform social practices, and what it can do for their activist-citizenship. In this way, aesthetics is central to enacting politics for climate justice (White et al., 2022).

Change is coming...

There is hope; the increasingly bright glimmer that we mentioned earlier. To once again return to the words of Harriet.

Now I am at a different school, and in our science classes we did a unit on climate change and ecology, as well as learning about the politics of climate change in other classes, that did not used to be part of the science curriculum at the school. I thought it was exciting to see that the curriculum is beginning to adapt to communicate the important issues of our time, particularly as it is a very mainstream school. (White et al., 2022, p. 33)

And Niamh:

Although education has come a long way and in junior levels the curriculum is more flexible for teachers to address climate change on a deeper level, the sense of urgency surrounding the issue means while the science behind it must be taught so students

understand the reasons to act and to create further public pressure, what needs to be taught is the socio-economic impact of climate change on the groups that already face systemic disadvantage. (White et al., 2022, p. 33)

If we read these climate change stories of Harriet and Niamh alongside Dawson et al.'s (2022, p. 1,394) finding that there are opportunities in the form of various aspects of science and geography curricula to activate climate science as the basis for an “interdisciplinary and deep-learning experience,” then we become aware of a potential shift in the aesthetics that frames our enactment of climate change education and the role of climate science.

The potential to realize such an aesthetic shift is perhaps best reflected in the recent forming of the *Environmental Science Expert Working Group* (of which second author, Peta White, is a member) as part of the latest work on the ‘PISA 2025 Science Framework’. This group was tasked with developing a construct to measure “the degree to which 15-year-olds are knowledgeable of, concerned about, and able to act on environmental issues as a result of their science education” (White et al., 2023, p. 1). The outcome of this group’s work is a positioning of climate science as part of climate change education in the form of a focus on “Agency in the Anthropocene”, which they define thus:

Agency in the Anthropocene requires understanding that human impacts already have significantly altered Earth’s systems, and they continue to do so. Young people with Agency in the Anthropocene believe that their actions will be appreciated, approved, and effective as they work to mitigate climate change, biodiversity loss, water scarcity, and other complex issues and crises. Agency in the Anthropocene refers to ways of being and acting within the world that position people as part of (rather than separate from) ecosystems, acknowledging and respecting all species and the interdependence of life. Those with Agency in the Anthropocene acknowledge the many ways societies may have created injustices and work to empower all people to contribute to community and ecosystem well-being. They demonstrate hope, resilience, and efficacy in the face of crises that are both social and ecological (socio-ecological). Moreover, they respect and evaluate multiple perspectives and diverse knowledge systems and demonstrate their ability to engage with other young people and adults, across the generations, in civic processes that lead to improved community well-being and sustainable futures. Young people with Agency in the Anthropocene work individually and with others across a range of scales, from local to global, to understand and address complex challenges that face all beings in our communities. (White et al., 2023, p. 7)

We consider this statement as advocating a transformative aesthetic. The *Environmental Science Expert Working Group* values climate science as part of a “new” science education that forms part of climate change education as an interdisciplinary undertaking that is focused not on fabricating disciplinary boundaries (yet at the same time it respects the epistemic integrity of each discipline) but rather is focused on addressing the socio-ecological issues that constitute the climate crisis. Our aim in the remainder of this paper is to explicate in our own way the form and function of this emerging aesthetic of climate change education for climate science (and thus for science education), and to make clear what it is that we offer that is new in

terms of such an aesthetic as framed by a Peircean/Deweyan pragmatism.

A “new” pragmatist aesthetics of climate change education

We argue that a shift in the aesthetics of science education is required, and indeed has already started to emerge in climate change education, in order for young people to enact climate science in transformative ways for them and the planet. We propose that to do so it is necessary to enrich Dewey’s (1934/1987) take on aesthetics with Peirce’s (1903/1998) notion of the three normative sciences, with “normative science in general being the conformity of things to ends” (CP 5.129)¹. Such an approach determines, in a radical way, that aesthetics ought not be considered in isolation as they always have ethical and logical implications. And more than this, from this perspective, we must realize aesthetics, ethics and logic as normative (as opposed to relative) in nature which means that there are ways of making value judgments, conducting ourselves and thinking which are better than others. Climate change education emerges from our efforts/endeavors as a necessary aspect of climate science as practiced in informal as well as formal science education settings. In doing so, we propose that the pragmatist approach to aesthetics still has much to offer science education, despite recent calls by Toscano and Quay (2021, p. 147) to go “beyond a pragmatic account of the aesthetic of science education” due its “limitations and shortcomings.” However, to realize these opportunities requires us to seriously engage with the writings of Peirce and undertake the challenging academic work required to put his ideas into action in ways that can meaningfully inform our educational theory and practice. We hope to go some way to doing so in this paper, expanding on our previous Peircean work.

As such our paper has two main threads: (1) introducing the reader to the fundamentals of Peirce’s aesthetics and thus his ethics and logic, (2) mapping the contours of a transformative aesthetics of climate change education. While the latter is the primary focus for us here, it can only be undertaken if we first address the former.

Normative sciences

Peirce divides his philosophy into phenomenology, normative sciences and metaphysics (CP 5.121), and then further divides the normative sciences into aesthetics, ethics and logic (CP 1.575). Peirce’s architectonic philosophy is grounded upon, and brings into being, objective idealism to account for the nature of truth and reality, such that: “The one intelligible theory of the universe is that of objective idealism, that matter is effete mind, inveterate habits becoming physical laws” (CP 6.25). So, Peirce is an idealist in that reality (including materiality) springs forth from the mind, but this is mind as general and indeterminate (Lane, 2018). He is an objectivist in that material objects exist independently of the individual observer and so (partially) constitute reality (Lane, 2018). Such a theory is distinct from both

¹ CP x.y=Collected Papers of Charles Sanders Peirce (1932, 1935, 1958), volume x. paragraph y.

materialism and idealism in its subjective form, and directly relates to Peirce's position as a scholastic realist in asserting the reality (although not existence) of generals and rejecting nominalists' prioritizing of discrete individuals (Forster, 2011). Peirce's philosophy is synechistic and tychistic in nature, meaning that the evolution of the universe is considered as continuous and punctuated with generative chance (CP 4.584). Most importantly for our current concerns, Peirce proposes: "The opinion which is fated to be ultimately agreed to by all who investigate, is what we mean by the truth, and the object represented in this opinion is the real" (CP 5.407). To be clear, this does not mean that the (infinite) community of inquiry determines the truth in any causal way, but rather that the community of inquiry is destined, as long as it appropriately executes the method of science, to indefinitely 'arrive at' the truth (Mayorga, 2007). This is truth as the ideal limit of inquiry, with the relationship (between truth and inquiry) appearing to be asymptotic but ultimately it is not (Cárdenas, 2018).

By a normative science, Peirce means that which "distinguishes what ought to be from what ought not to be" (CP 1.186), or "the science of the laws of conformity of things to ends" (CP 5.129). It's important to point out here that while for Peirce it is imperative for aesthetics, ethics and logic to be normative, we do not always meet this standard in our daily lives. In our efforts to realize the ultimate aesthetic, ethical and logical forms (more on this below), we progress through a series of imperfect forms. The point Peirce is making is that there are definitively (i.e., normatively) "good" and "bad" ways for us to be aesthetic, ethical and logical, and we need to do more of the former than the latter. Indeed, in order to realize the perfect forms, we must only do the good and not the bad; we must strive for the ideal. As we progress down this normative path, we should keep in mind Peirce's comment about the diverse ways in which aesthetics, ethics and logic play out despite (or perhaps because of) their normative nature:

Normative science ought to examine all questions relating to the possible ends of phenomena. Not merely what the ends are and what are the conditions of conformity to those ends, or their mere quantity of goodness and badness, but also, the diversity in the different paths by which such ends may be pursued, and the different stadia in those paths: as well as the different ways in which the ends may be missed. [Peirce (1903/1998), draft of *Harvard Lectures*: 9, as cited in Liszka (2021), p. 3]

From an educational perspective, this means that we need to enact science education such that it gives us a humanity that has the potential to appreciate a diversity of aesthetics, ethics, and logic.

So how does Peirce define aesthetics, ethics and logic? He does so in a way that is aligned with Dewey's work, but which is more logical than psychological in nature: "Esthetics considers those things whose ends are to embody qualities of feeling, ethics those things whose ends lie in action, and logic those things whose end is to represent something" (CP 5.129). As Liszka (2021, p. 2) proposes, "Peirce strikes out his own path for the unity of truth [logic], goodness [ethics] and what ends are best to pursue [aesthetics]." These normative sciences form an onto-epistemological triptych for Peirce as framed by his broader semiotic pragmatism:

...if, as pragmatism teaches us, what we think is to be interpreted in terms of what we are prepared to do, then surely logic, or the

doctrine of what we ought to think, must be an application of the doctrine of what we deliberately choose to do, which is Ethics.... But we cannot get any clue to the secret of Ethics...until we have first made up a formula for what it is that we are prepared to admire. (CP 5.35)

Liszka (2021) unpacks what Peirce means by this triptych in terms of the normative form:

Esthetics is the study of admirable ideals, and what makes ends worthy of pursuit. Ethics is the study of which ends ought to be deliberately adopted, that is, those that are good for no ulterior reason or interest, but simply good in themselves. It also has the job of determining right conduct in pursuit of those ends. Logical - or scientific reasoning broadly - would be *in this context of normativity* concerned with reasoning from means to ends, that is, what is likely to attain the ends-in-view" (Liszka, 2021, p. 65).

To put this in a simplified form, for Peirce; logic (how we ought to think) rests on ethics (how we ought to conduct ourselves) which is grounded in aesthetics (how we ought to value). So, it's not just the dependence of ethics on aesthetics and in turn the dependence of logic on ethics (and thus on aesthetics) that is key to Peirce's revolutionary philosophy, but also that each of these is normative in nature and thus there are ideal ways for us to make value judgments, conduct ourselves and reason. To be sure, Peirce is building on the work of key philosophers such as Kant and Hegel (among many others) in delineating this triptych. But particular to Peirce is his insistence on the primacy of aesthetics as a normative force in driving inquiry on the path to the truth in an objectively ideal world, that is a world that is devoid of things-in-themselves (so non-Kantian) and consists of actions and feelings (so non-Hegelian) as well as laws (Cárdenas, 2018).

The question then, of course, is what are these ideals and how are they determined? And further to this, what is the relationship between these ideals and our daily aesthetics, ethics and logic? As we will explore next, and as we have already hinted at, Peirce determines ideals in a logical way, and argues that the individual will never realize these ideals (in their daily practices) but rather it is only the community (which for Peirce has a very specific meaning) that can do so (in general and indefinitely). In what follows, we aim to make clear that the norms of aesthetics, ethics, and logic are determined by the truth, in that what we ought to value, how we ought to conduct ourselves, and how we ought to think, must be aligned with inquiry as the road to the truth. However, for Peirce, this ideal process is always filtered through the more practically philosophical lens of sentiments and intuitions, thus sidestepping Hume's guillotine, which drive our everyday beliefs and actions (Atkins, 2016). All of which speaks to the complex nature of the practice/theory nexus (and indeed the is/ought nexus) from the Peircean perspective (CP 1.616).

Peircean aesthetics

The philosophical situation is complicated when the three normative sciences are explicitly stated in ideal terms as dictated by Peirce's approach. In the case of aesthetics: what we ought to ultimately value (i.e., what ends are best to pursue) is what is "admirable *per se*" (CP 1.613) or "admirable in itself" (CP 1.614), which for Peirce is "a quality of feeling" (CP 1.614) that "must, no doubt, be general" (CP 1.613) due to its ideal nature. Peirce goes on: "...since we are

seeking for that which is fine and admirable without any reason beyond itself, pleasure, bliss, is the only object which can satisfy the conditions" (CP 1.614). It is in this way that aesthetics, for Peirce, is concerned with "kalos" (CP 2.199), as [Liszka \(2021, p. 189\)](#) explains: "To *kalon* connotes something more than beautiful appearance for Peirce. It is something noble, good, admirable, and loveable." As such, what we ought to feel as kalos in itself is what is admirable *per se*. It is important here to remind ourselves that in striving to realize this ultimate aesthetic form in our daily lives that we are constantly considering "what it is that we are prepared to admire" (CP 5.36); this is aesthetics in action. The full meaning of what Peirce means by the perfect aesthetic form is only comprehensible in relation to what he states about the normative nature of ethics, as [Liszka \(2021, p. 179\)](#) puts it: "...the primary role of aesthetics is to determine what design, form, or organization of things would best fit its end, and ethics has the role of determining which ends are good." So, it is ethics that we must now explore.

Peircean ethics

Peirce considers the normative nature of ethics in terms of the *summum bonum*, which is the "ultimate end" (CP 1.588), so the highest or ultimate good. As such, the *summum bonum* constitutes also the actions that are required to realize this ultimate end, for ends are defined by the actions that make them possible. We must remember that for Peirce, ethics is about "what is the ultimate end to be pursued, and what sort of conduct is most conducive to that end" ([Liszka, 2021, p. 67](#)). Peirce argues that our actions ought to be directed toward "the development of concrete reasonableness" (CP 5.3), in such as "the highest of all possible aims is to further concrete reasonableness" (CP 2.34). By concrete reasonableness, Peirce means:

... the ideal of conduct will be to execute our little function in the operation of the creation by giving a hand toward rendering the world more reasonable whenever, as the slang is, it is 'up to us' to do so" (CP 1.615)

As such, how we conduct ourselves ought to be aligned with the aim of making the world more reasonable, so that ideal conduct is conduct that begets "purposive, self-correcting conduct" ([Liszka, 2012, p. 63](#)). As [Liszka \(2012, p. 64\)](#) puts it, "it is the goal of continuing to make one's life reasonable that matters." In this way, Peircean ethics is concerned with "self-controlled, deliberate conduct" (CP 1.191) in that our conduct ought to "conform to a purpose or ideal" (CP 573). Our conduct comes in the form of habits that we are aware of and can change in ways aligned with the ultimate aim. To be clear, this is not the meaning of habit as a set of predetermined actions (which threatens the agency of entities including humans), but rather habits as dispositions to likely act in particular ways in particular circumstances. Not only can we become aware of our habits, but we can change them in purposeful ways; this is what makes us human. In this way, we can talk of Peirce's "definition of ultimate meaning as habit" ([Liszka, 2012, p. 141](#)) and further to this the "improvement by means of habit-change, conscious modification of existing habits and even deliberate planting of relatively new habits" ([Liszka, 2012, p. 140](#)). The implications of Peirce's position on ethics are clear; to a large extent, we determine our own actions, how we conduct ourselves. But there are ways of conducting ourselves that

we ought to realize as they are ideal, which we can think of as "adequate habits" ([Liszka, 2012, p. 141](#)). For Peirce, just as there are good and bad value judgments, there are good and bad habits (relative to the ultimate ends). And, as we now know, for Peirce, our conduct is dependent on our value judgments, with our conduct in turn determining our reasoning, as Peirce explains; "it is only after the moralist has shown us what is our ultimate aim that the logician can tell how we ought to think in order to conform to that end" (CP 8.158). So, it is logic that we now consider.

Peircean logic

As [Liszka \(2021, p. 64\)](#) states, "logic is a study of right and wrong reasoning," with Peirce framing logic "as the art of reasoning" (CP 5.363). But what does Peirce mean here by right and wrong, in other words what is ideal reasoning for Peirce? We must remember here that concrete reasonableness is the ideal of ethics, so we need to know more of what Peirce means by reasoning if we are to properly understand his ethics and in turn his aesthetics. We must first understand what Peirce means by reasoning, which for him is "to find out, from the consideration of what we already know, something else we do not know" (CP 5.365). Humans, according to Peirce, are driven to resolve doubt (i.e., not knowing) by replacing it with beliefs in the form of habits (i.e., our beliefs determine our actions). Logic is a matter of ethics in the sense that reasoning concerns habits of thinking (good and bad thinking); how we conduct our thoughts is a logical as well as an ethical matter. It is in this way that Peirce claims, "the irritation of doubt causes a struggle to attain a state of belief" (CP 5.374), with Peirce referring to this process as "inquiry" (CP 5.374). Now, for Peirce, the ultimate end of inquiry, or in other words the ideal limit of inquiry, is the truth. So, for Peirce, "truth is that concordance of an abstract statement with the ideal limit toward which endless investigation would tend to bring scientific belief" (CP 5.565). Thus, we can say that inquiry is the pursuit of the truth, and so logic as a matter of reasoning concerns the truth. The reasoning that is manifest in ideal ethical form as concrete reasonableness is the method of science.

This statement by Peirce about the nature of truth reveals his argument that truth can only be realized by a community that enacts reasoning according to "the method of science" (CP 5.384), which is aligned with reality as "that mode of being by virtue of which the real thing is as it is, irrespectively of what any mind or any definite collection of minds may represent it to be" (CP 5.565). Peirce in this way talks of the method of science as accountable to "some external permanency" (CP 5.384). His notion of community as an "unlimited community" (CP 2.654) or "indefinite community" (CP 2.655) is radical in the sense that this community is not constituted by a definite collection of individual humans, but rather is composed of an indefinite number of intelligent entities capable of thinking (i.e., reasoning) as/through signs. At this stage it is important to remind ourselves that reasoning, for [Peirce \(1894/1998, p. 10\)](#), is a semiotic phenomenon and so "the art of reasoning is the art of marshalling such signs, and of finding out the truth." Peirce's framing of community in this way leads to a radical conclusion:

Thought is not necessarily connected with a brain. It appears in the work of bees, of crystals, and throughout the purely physical world; and one can no more deny that it is really there, than that the colors, the shapes, etc., of objects are really there... ([Peirce, 1906, p. 523](#))

We argue that Peirce can be read here as suggesting that intelligence in the sense of thinking as reasoning for meaning making is not limited to humans, but rather is undertaken by all entities that are capable of semiosis that includes biotic and abiotic entities. As such, reasoning is not strictly a human affair, even if logic is (for logic is the art of reasoning as opposed to reasoning in itself). However, humans are capable of particular forms of reasoning that are not undertaken by other entities, in particular the generation of arguments, but this does not devalue other forms (e.g., terms and propositions).

Now it is our turn to make a provocative claim; in order for humans to realize reasoning in its ideal form, we must form a “quasi-mind” (CP 4.536) with all other biotic and abiotic entities capable of semiosis. We thus suggest that there is a more-than-human element to Peirce’s notion of logic as the outgrowth of ethics and aesthetics. In doing so, we fully endorse Legg’s (personal correspondence, April 20, 2023) notion of “pan-species realism” to characterize Peirce’s account of meaning and being in/of the world as sign-centered (not human-centered). However, we stop short of suggesting that Peirce is a post-humanist scholar *per se*, but nevertheless we argue that there is a potentially productive synergy between Peirce’s work and the current burgeoning of post-humanist scholarship, particularly when it comes to the current climate change crises. As we continue to explore this conceptual territory, we endeavor to engage with the work of Peircean scholars such as bio-semiotician [Stjernfelt \(2014\)](#) who highlight the potential to go beyond the human in Peirce’s work.

We are now able to more clearly state what we mean when we say that the norms of aesthetics, ethics, and logic are determined by the truth. If the summum bonum is concrete reasonableness, then the ultimate form of this is the truth, and so the norms of logic, ethics and aesthetics ought to align with this aim of the truth that is the ultimate opinion of the indefinite community eventually determined through scientific reasoning. In doing so, we must necessarily propose that the truth in this form is admirable in and of itself, in order for aesthetics to maintain its position at the base of the normative sciences.

Aesthetic, ethical, and logical imperatives of climate change education

[de Mesa \(2018, 249\)](#) points out that Peirce’s account of the three normative sciences has important implications for education: “if aesthetics is normative for ethics and logic, in the sense that it establishes the admirable *per se*, an aesthetic education should be at the basis of any pedagogical endeavor.” We invert this statement to emphasize that a full understanding and appreciation of an aesthetic of climate change education is dependent on determining the ethical and logical entailments of this aesthetic. To enact an aesthetic of climate change education is to necessarily enact an ethics and logic of climate change education, which must be normatively grounded if we are to stay true to Peirce and to be responsive to our collective ideal for climate change education in the Anthropocene. While in this paper we can make explicit these links between aesthetics, ethics and logic for climate change education, it is beyond our scope to present in any definite form these aesthetic, ethical and logical elements as they ought to manifest in climate change education to align with the ideal forms.

To reiterate a point that we alluded to earlier; ideal forms are by their very nature absolute and so transcend disciplinary boundaries. Therefore, the focus of demarcating the aesthetics of any particular

discipline is to determine the value judgments that would align with the aesthetic ideal (i.e., admirable *per se*). And, as we are invoking Peirce’s aesthetics to do so for climate science as part of climate change education, then we must also determine the conduct and reasoning that would align with the ideals of ethics and logic (i.e., concrete reasonableness and scientific method). This work of demarcating aesthetic, ethical and logical boundaries to align with the ideals will only emerge from the community, of which we are but two members, as we explain in our conclusion to this paper. Before exploring these “new” aesthetics, ethics and logic for climate change education, it is worth pointing out that as we shift from aesthetics to ethics to logic that these disciplinary forms increasingly align with the ideal forms (e.g., the logic of climate change education is the method of science albeit in an imperfect form).

A new aesthetics

We thus invoke [Peirce’s \(1903/1998\)](#) three normative sciences to argue that we cannot stop at aesthetics *per se*, but must extend to ethics and logic if we are to realize a transformative aesthetics of climate change education; a new taste for climate change education. We draw on [Dewey \(1934/1987\)](#) to propose that teachers, and other adults in the role of educator, need to work with young people to develop those value judgments which explicitly include climate science and its particular objects as part of science education. It is essential that this shift in valuing of climate science as part of climate change education (and vice versa, so climate change education as part of climate science) is systematic in nature in that it plays out at the curricula and policy levels which impacts both formal and informal educational settings. We propose that this process of inclusion leads to climate change education, and climate science as part of this undertaking, as a transdisciplinary endeavor that focuses on addressing those socio-ecological challenges that define the Anthropocene.

This is not climate change education as just another “subject”, but a reimagining/re-realization of science education that acknowledges the importance of disciplinary boundaries but not at the cost of an overarching transdisciplinary aesthetic. Our conclusion here is clear, at least in regard to an aesthetics of climate change education; we need to understand and value distinct disciplinary aesthetics, but these must be positioned relative to a transdisciplinary aesthetic that innervates each and every disciplinary aesthetic in different ways. Such a transdisciplinary aesthetic is all about valuing the contributions that distinct ways of knowing and being can make to addressing the socio-ecological challenges of the Anthropocene. It is only by doing so that we can realize the beauty (in the sense of *kalon*) of climate science on the path to experiencing bliss of the admirable *per se*.

A new ethics

If we adopt such an aesthetics of climate change education, then from our Peircean (1903/1908) perspective we must take particular actions that set us on the path to realizing specific ends. We argue that these ends for climate change education ought to be the activation of climate science by young people with us (intergenerationally) to firstly understand the socio-ecological challenges and then to resolve these issues such that the integrity of all entities’ existence is assured in a form of harmony/homeostasis. These are ways of acting, including most importantly reasoning, that not only enable understanding of the science of climate change but afford informed practices of changing our (as humans) relationships with the rest of the biotic and abiotic world to respect all beings’ quiddity (i.e., the essence of each being).

Such ethics underpins the important role played by climate science as part of climate change education to foster the development of young people as scientifically-agentive citizens of the Anthropocene. We, and our science education colleagues, like to talk about science education as inducting students into science as a way of being in the world; we now suggest that such a manifesto only makes sense if framed as an ethical endeavor as grounded in aesthetics.

Climate change education from this Peircean perspective on ethics ought to be an intergenerational endeavor (involve adults working with young people, and vice versa) to become aware of our existing habits of climate science in order to alter these dispositions such that they better align with the desired ends. In this way, climate science as part of climate change education is the ongoing and purposeful development of a set of particular habits. We argue that such habits and ends (see paragraph above) are aligned with the ultimate ethical ideal of concrete reasonableness because climate science is activated as part of climate change education so that young people can make meaning of the world in a caring way (more about this in our conclusion to this paper).

A new logic

What about the final member of our normative science triumvirate, that is the logic of climate change education? We proposed earlier that, for Peirce (1903/1998), the reasoning that is manifest in ideal ethical form as concrete reasonableness is the method of science. As such, we propose that climate science as part of climate change education ought to involve young people working together and intergenerationally as a community to undertake reasoning in the form of abduction, induction and deduction as informed by evidence about climate science phenomena that affords explanation of certain aspects of such phenomena. Young people need to be supported to tune into the climate ‘surprises’ of the natural world so they can generate and test hypotheses to explain the current crisis and take informed action in forms other than reasoning (remembering that ethics encompasses all habits). Only by doing so can young people effectively argue for climate justice.

However, as we flagged earlier, while Peirce (1894/1998, 1907/1998) limits argumentation to humans, he asserts that reasoning and thinking more generally (including terms and propositions as well as arguments) are undertaken by all intelligent entities to varying degrees to determine the truth. The radical entailment of this notion of truth for a logic of climate change education as grounded in climate science is that young people ought to not just collaborate with all humans but with all biotic and abiotic entities capable of semiotic activity for meaning making. Climate change education must be grounded in the community, and this community must expand well beyond the walls of the school classroom such that young people can enact climate science with the more-than-human. This is the only logic of climate science as part of climate change education that can align with the method of science as an ideal, which if we remember is an imperative of our transformative aesthetics of climate change education.

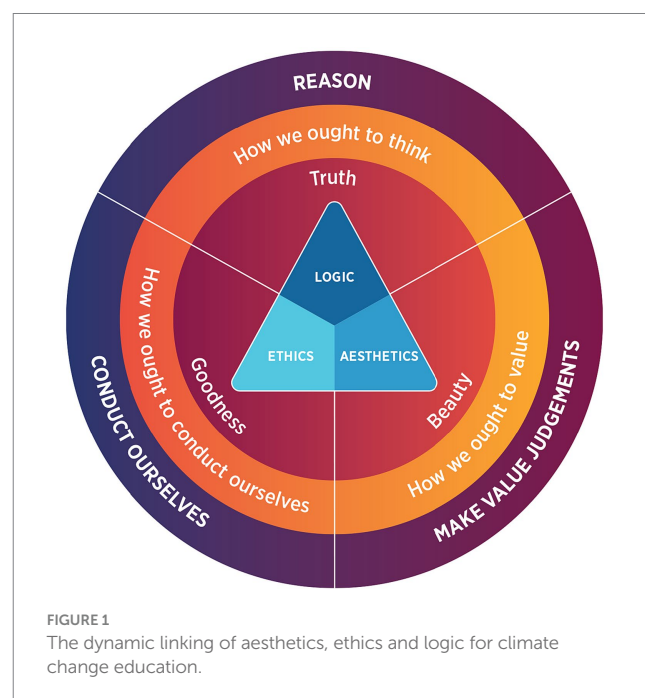
A new aesthetical-ethical-logical triptych for climate change education

We present in Figure 1 a new perspective on aesthetics and thus ethics and logic for climate change education, and in particular a provocation as to the important role that climate science ought to play

in such a science education for the Anthropocene. In exploring this model, we aim to provide the full range of climate change educators with suggestions as to going about realizing climate science as a driving force of climate change education for loving and hopeful futures (more on this in the conclusion). In addition, in presenting this model of the triptych, we agree with Wickman (2017) that aesthetics, ethics, and logic are intertwined in practical experience, including in the context of science education. However, we differ in arguing that this ordering of the normative sciences (starting with aesthetics) is not simply an arbitrary convention of the analytic tradition in philosophy, but rather it reflects a fundamental aspect of being that makes possible a satisfying and worthwhile life.

We propose, following Peirce, that enacting climate change education ought to begin with aesthetics and in turn develop ethics and finally embrace logic. Such an ideal is exemplified by the young people of Youth for Sustainability/School Strike 4 Climate as they take as their starting point for activism/education how they value, which determines how they conduct themselves that in turn leads to how they think, all in relation to human-induced climate change. The stories of Niamh and Harriet in our recent paper (White et al., 2022) are testament to the power of this radical version of climate change education to make our world better, as they come to know and put into practice the epistemic power of climate science (logic) through the need to act in ways to “save” their communities (ethics) as necessitated by their loving of all entities on Earth including climate science as part of climate change education (aesthetics).

Young people can enact the normative sciences in this way because they consider climate change education and more specifically climate science as a matter of addressing socio-ecological issues by putting into action any and every discipline, as opposed to artificially siloing ways of knowing and being (including climate science). This is not to say that such climate change education ought to demolish all disciplinary boundaries; to the contrary, the specific aesthetics (and so epistemic integrity) of all disciplines must be respected at the same time as



we embrace an aesthetic for interdisciplinarity (i.e., epistemological pluralism). We also emphasize that there is always more that can be done to bring us closer to the aesthetical-ethical-logical ideal. In the case of the young people of Youth for Sustainability/School Strike 4 Climate, they are in need of intergenerational collaborators who can support them to bolster their logic by realizing the method of science (in particular the knowledge and practices of climate science) in more complete ways. Climate scientists are faced with the contrasting challenge as while their logic is fully formed (they know well the science of climate change and its grounding in the method of science) they are in need of guidance to bolster their aesthetics and ethics when it comes to climate change education (i.e., valuing climate science as part of valuing the Earth to guide caring actions). As such, there is always scope to change our habits; it will take time and energy to develop this new taste for climate science as part of climate change education.

All of this is a reminder that those involved as students and teachers in climate change education will vary in terms of their starting points for enacting climate science; some will start with logic, others with ethics and still others will ground their being with/as climate change in aesthetics. It's up to us as advocates for transformative climate change education to work with young people and their adult allies to acknowledge these different starting/entry points and to map out ways to move between logic, ethics and aesthetics, for this triptych is not linear and static but rather dynamic and non-linear. In doing so, we stress the need to prioritize and foreground aesthetics, but always with ethics and logic in mind (as well as in body and spirit). And, as advocated by Peirce, we must go about all this as a process of (endless) semiosis; "all this universe is perfused with signs" (CP 5.448).

A radical pragmatist meliorism for the future

We conclude our paper on a hopeful and loving note, as we endeavor to contribute to efforts to realize a much needed "praxis of radical love and critical hope for science education" (Torres Olave et al., 2023, p. 1). We propose that if we adopt our transformative aesthetics of climate change education that this makes possible - once again by fusing Dewey (1934/1987) with Peirce (1894/1998, 1903/1998, 1907/1998) - a radical pragmatist meliorism to productively negotiate the challenges of the Anthropocene intergenerationally and with the more-than-human. This is a meliorism that is underpinned by the three normative sciences, the most fundamental of which is aesthetics, and which emerges from the pan-species and intergenerational community of inquiry.

Meliorism, according to Peirce, is the:

- (1) improvement of society by regulated practical means: opposed to the passive principle of both pessimism and optimism.
- (2) doctrine that the world is neither the worst nor the best possible, but that it is capable of improvement: a mean between theoretical pessimism and optimism. Peirce (1899), entry for Century Dictionary, as cited in Bergman (2012, p. 127).

Dewey similarly considers pessimism and optimism as paralyzing forces when it comes to making changes for the better, and so advocates for meliorism as:

...the belief that the specific conditions which exist at one moment, be they comparatively bad or comparatively good, in any event may be bettered. It encourages intelligence to study the positive means of good and the obstructions to their realization, and to put forth endeavor for the improvement of conditions. [Dewey (1899-1924/1980), in *The Middle Works of John Dewey*, pp. 181-182, as cited in Bergman (2012, p. 128)].

Bergman (2012, p. 128) refers to Dewey's meliorism as an "explicit activist conception of meliorism." We propose that to avoid utilitarianism that Dewey's account ought to be complimented by Peirce's insistence on the importance of all actions (not just 'practical') including those which are theoretical/philosophical in nature.

We are all aware in our work as science educators with young people that the socio-ecological issue of human-induced climate change is a strong cause for pessimism and that optimism often leads to "toxic positivity" (Lobo et al., 2021, p. 1,496). As such, this pragmatist meliorism offers genuine hope in that we can - through the changing of our aesthetic, ethical and logical habits of climate science as part of climate change education - realize ways of valuing, conducting ourselves and thinking that make this world better for all. Indeed, we have witnessed, and will continue to do so, this meliorism in action as the youth climate movements. We follow Liszka (2021) and Anderson (1995) in highlighting the all-encompassing nature of this meliorism in that it is realized by a community that is not only intergenerational but also pan-species in nature; it involves all entities capable of semiosis in the here and now, and the future. We concur with Liszka (2021) that such a community committed to meliorism is a force for what Peirce refers to as "evolution by creative love" (CP 6.302), which he conceptualized with his notion of "agapism" (CP 6.302). It is worth quoting Peirce at length here to make clear what he means by agape/love:

The movement of love is circular, at one and the same impulse projecting creations into independency and drawing them into harmony. This seems complicated when stated so; but it is fully summed up in the simple formula we call the Golden Rule. This does not, of course, say, Do everything possible to gratify the egoistic impulses of others, but it says, Sacrifice your own perfection to the perfectionment of your neighbor. Nor must it for a moment be confounded with the Benthamite, or Helvetian, or Beccarian motto, Act for the greatest good of the greatest number. Love is not directed to abstractions but to persons; not to persons we do not know, nor to numbers of people, but to our own dear ones, our family and neighbors. "Our neighbor," we remember, is one whom we live near, not locally perhaps but in life and feeling. (CP 6.288)

It is imperative here to reiterate Anderson's (1995) point that by "neighbor" Peirce does not just mean humans but all entities capable of semiotic activity, such that agape is love for all in a benevolent/altruistic and not self-serving way. As Liszka (2021, p. 138) argues: "It is a willingness to contribute to present and future communities, to make things better and pass it on to those that follow, even if one does not benefit oneself from such contributions." We believe that a transformative aesthetics of climate change education can put us and young people on the path to love through the power of climate science for hopeful futures.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

JF: Writing – original draft. PW: Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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