

Science education needs manifestos^{+,*}

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Abstract

As a science teacher educator, manifestos are usually something I have students write. Manifestos are bold forms of expression that help earnest people formulate a focussed or principled stance on important issues. This special issue has provided an opportunity to write a short manifesto of my own; and it is good practice to do the things you want your students to do. In times of increasing environmental and social precarity, science and science education can no longer deny the moral and ethical imperative to be relevant to the survival of both human and nonhuman life. What follows is a manifesto that addresses some of what science education needs to grapple with in times of right-wing populism, pandemic, pollution, and political need. It's not intended to be a platform, because science education needs many manifestos of desire and intent. The best this manifesto can do is encourage teachers and students to write more inspiring ones. The language of manifestos is highly variable, but generally it take things like declaration and affect more seriously, and leaves the important tasks of elaboration and consensus for another day. This manifesto has been organized into eight parts that together maintain that science, education, environment, and politics are necessarily entangled, such that the time where one could pretend that the sciences are separate from, and/or superior to, everything else has passed. Second, that boundaries separating things like disciplines, different species, and different ways of knowing the world are proving to be more arbitrary and less useful than ever.

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To privilege text flow and keep the style of the manifesto, the invited author chose to use footnotes for references.

Manifestos, which are unabashedly political and morally invested, are just one of a multitude of unorthodox transdisciplinary manifestations coming to science educational communities everywhere!

Keywords: *Manifestos; Education; Science Education; Science; Populism; Politics.*

I. Introduction: Manifestos as expressions of desire and intent

¶ **Freedom to Write** - When students are given the freedom to write manifestos about issues of collective importance each one turns out very different. One reason for this is that everyone's dreams and desires are intricately attached to different collectives. It's impossible to have a dream for the future without it differing from other dreams, no matter how much we wish to dream the same dream. But the reverse is also true. It is impossible to have different dreams without a vibrant commons, which provides the material for thinking and acting differently². This manifesto should look peculiar, yet feel somewhat familiar at the same time. The neglect of either the familiar, what makes us family, and the peculiar, what makes us special, is a major dilemma for education. If science education were to honour both, the familiar and the peculiar, for example by honouring a much more expansive conception of science and education, it would likely become one of the strongest ethical forces for building sustainable collective futures. The COVID-19 pandemic has brought questions of collective existence close to everyone. Science and collectivity go together because, simply put, they both rely on sharing. Conversely, privatization, parochialism, and hegemony are antithetical to collective futures that take science seriously, because they seek to erode and exploit what we share in common. This contrast couldn't be more visible than in Brasil, where right-wing populism is accelerating environmental destruction and eroding common resources and institutions.

¶ **New/Old Problems** - Educators are right to want to understand the different social, cultural, political, and historical contexts in which they labour and live. The problems educators face today have twists nobody could have quite pictured. If they could, the discipline of history would give way to a science of human destiny or fortune telling. From one perspective, the COVID-19 pandemic has simply exposed problems of economic and ecological precarity that were there beforehand. It's a very obvious and relevant question today to ask whether people's lives or the growth of capital matters more. Our current educational context is also contending with new material and existential threats: new right-

² For more on the relationship between multiplicity and the commons, and how they mutually constitute each other, see Michael Hardt and Antonio Negri's *Empire*. Harvard University Press, 2000.

wing populisms built on the deficiencies of neoliberalism, new forms of colonialism that draw on the same forces of dispossession and exploitation, the continuation of gender-based violence, and an even more tenacious capitalism that seeks to enclose our shared commons with renewed desperation. This is just some of the trouble that's visible from my very small vantage point, which would be impossible for me to see unless I had the help of my fellow educators³.

✂ **Collective Desire** - The eight movements of this manifesto are only useful if they enable something in educators, students, and scholars. You'll find that the movements circle back to two basic themes that are increasingly characterizing science education:

‡ Political entanglement

‡ Disappearing boundaries

Any serious debate as to whether science education should engage with politics, activism, and justice is now more or less moot⁴. The human-induced conditions of planet earth have made this debate laughable and sad — understanding too that some humans, e.g. the Global North, non-Indigenous, etc., bear more responsibility for creating ecological and social precarity. The 'far right wing'⁵ has emerged with subtle new attacks on science that have a distinctly twenty-first century character. The far right today submits scientific expertise to the kind of populist advertising that will either: 1) bend science to its own aims; or 2) attempt to obscure relevant findings and recommendations of science by pitting it as an adversary of right-wing populist interests⁶. Why science and education are so integral to the future is that most people desire new forms of collectivity. The good news is that different forms of collectivity will inevitably form, ecologically or socially⁷. That's just how our world works on an ontological level: difference always emerges.

³ See this manifesto conceived with Marc Higgins and Maria Wallace: Higgins, M., Wallace, M. F., & Bazzul, J. (2019). Staying with the Trouble in Science Education: Towards Thinking with Nature—A Manifesto. In *Posthumanism and Higher Education* (pp. 155-164). Palgrave Macmillan.

⁴ For a discussion on a 'sociopolitical' turn in science education see Sara Tolbert and Jesse Bazzul "Toward the sociopolitical in science education." *Cultural Studies of Science Education*, 12.2 (2017): 321-330.

⁵ It is important to identify the far right as a problem, but problematic to not explore what the far right might entail. I suggest the far right is any political force that attempts to privatize what should remain in-common to all either spiritually, economically, environmentally, socially, culturally, intellectually, etc.

⁶ This can be seen in the United States at this moment with the attacks on the Center for Disease Control and Prevention, but also the undermining of the widely respected Dr. Fauci. The appeal by the right is to some other higher authority of truth that cultivates a mistrust of science and action for the collective good. See this article: Rogers, K. Trump Pointedly Criticizes Fauci for His Testimony to Congress. *The New York Times*. May 13, 2020.

⁷ This can be seen in the multispecies ethnographic studies such as those from Anna L. Tsing. *The mushroom at the end of the world: On the possibility of life in capitalist ruins*. Princeton University Press, 2015.

✚ **Many Manifestos** - It is most useful to consider this manifesto as just one constellation of points amongst an array of others that should be written and recorded by teachers and students who care about our shared world in different ways. On both a material and abstract level, there are many points to plot in order to grasp this ecological and historical moment for science education. The only recourse for educators contending with environmental destruction and social inequality is to engage the matters of concern that give shape to both education and science. Manifestos as a form of political discourse implicitly declare equality⁸ as an ontological principle of existence. They do so by both making differences and different beings come to count equally, and by introducing new abstract universals that allow difference to thrive. Since, on a conceptual level universals and differences can be at odds with each other, there will always be productive tensions in manifestos. But these tensions also make space for new relationships between politics, science and education.

II. An open ethos of science and education in a time of right-wing populism

Δ **An Aporia** - No matter how smug people might get about the human cultural phenomenon called modern science, one thing its theories and methods cannot do on their own is establish science's ethos, purpose, or self-conception. These must come from ways of knowing and being that mostly originate outside of science and its methods. This is because the methods of verification, correlation, falsification, etc. that science has developed, and employed in marvellous ways, cannot be used to validate, or invalidate, the purposes, uses, or ethics of science. The narratives and ideologies that help shape and steer science, such as free market liberalism or a notion of social progress, do not submit to science's strict legitimation methods (nor are science's methods a guide to ethics)⁹. Even something as basic as Robert Merton's 'norms of science' are arguably not derived from scientific investigation itself (though scientific practices can be studied for ethical content and values)¹⁰. This opens up a

⁸ Equality here doesn't mean sameness, but instead can be seen as a radical democratic principle. See Jacques, Rancière. *Dissensus: On politics and aesthetics*. Bloomsbury Publishing, 2015.

⁹ The separation of narrative and scientific knowledges used here comes from Jean Francois Lyotard's *The Postmodern Condition*, which was a report on technology and science written for the government of Quebec. Postmodernism may involve incredulity of overarching metanarratives (human ideas), but Lyotard also warns of the systemization of knowledge that networks only what is useful and leaves all other knowledges behind. The work introduces a problem of knowledge rather than a relativization of knowledge so often associated with postmodernism. See Jean-François Lyotard. *The postmodern condition: A report on knowledge*. University of Minnesota Press, 1984.

¹⁰ Sociologist of science Robert Merton's norms of science, which are communism, universalism, disinterestedness, and organized scepticism, are still very instructional today are: See Robert K. Merton's, *The normative structure of science. The sociology of science*. University of Chicago Press. 1973.

productive aporia for science and science education: which is that the most powerful human cultural development(s) for producing knowledge — modern science — cannot use its powerful legitimation methods for providing the reasons or ethos for doing science, what the sciences should be used for, or any moral/ethical position for science existing in the first place.

Δ Looking Outside - This basic fact — that science cannot use its own methods to establish an ethos or purpose — means that science educators, if they are concerned with building better futures¹¹, must simultaneously look outside of science — to history, spirituality, economics, etc. — in order to give science and science education an ethical narrative, or a narrative of any sort (good, bad, benevolent, violent, etc.). This is one reason why anyone who says science education shouldn't be transdisciplinary, or socially, politically, environmentally, historically anchored is seriously impoverishing science education. They also likely do not understand where their own ideologies and values come from, which can be very dangerous in this current political climate! Science education is an art form, humanity, humanitarian discipline, technical trade, and sociological field of study. Science educators are responsible for exploring those things that give science an ethical orientation and meaning. Because this orientation and meaning will never come from the methods of science itself, or for that matter their direct results. If the ethics, contexts, and purposes of science are not engaged by educators, potentially more sinister forces, such as advanced capitalism, will fill in this ethical void. Science education must seek more creative ethical planes of thought and contextualization for scientific study and investigation.

Δ Right-wing Populism - Right-wing populism today is not just a danger to environments, equality, and public institutions, but the enterprise of science itself. We see this in the populist right's new attacks on science in the form of paid lobbyists and spokespeople whose job it is to sow discord and doubt in the findings of science, or cast scientific institutions and/or research in an unfavourable light¹². Attacks on the results of science further demonstrate there is no possible space of neutrality. Neutrality today can be as violent as any other possible political position, although a leftist or collectivist one at least directs its violence toward the destruction of the mechanisms, technologies and ideologies bent on

¹¹ To be clear, many science educators are not actually interested in changing the world for the better. This is very likely due to the ideologies and structural conditions that allow them to detach science from a more comprehensive and relevant ethical and educational vision. This hit home for me when science teachers in my city (Regina, Canada) discouraged their students from participating in the worldwide school climate strikes.

¹² For example, the fossil fuel industry exerts influence over schooling in a number of ways, including in places with strong commitments to public schooling (like Saskatchewan, Canada). See Emily Eaton and Nick Day's "Petro-pedagogy: fossil fuel interests and the obstruction of climate justice in public education." *Environmental Education Research* 26.4 (2020): 457-473.

environmental destruction and domination. What makes the current right-wing positions so dangerous is that they openly oppose the collective desire for action on massive social issues and environmental protections. Right wing populism, backed by state agents and industry, tries to tarnish the image or findings of science whilst also trying to turn science against matters of collective concern. Their tactics are affective-semiotic capture, or news rumours, claiming to either not have all the facts or, worse yet, alternative facts.

Δ Transdisciplinarity - Without a transdisciplinary science education, science educators (and scientists) are powerless against purposeful misinformation, political attack, and to positively set an ethics and purpose for science education. Science educators need a tenacious response to delegitimization. But, perhaps more importantly, educators need to be able to identify and understand what fuels these sorts of attacks, and how exactly narrow short-term interests are served ahead of the collective good. It should be remembered that right wing media outlets, pundits, lobbyists, think tanks and large corporations have paid strategists on their side. An important question to ask is who seems committed, judged by their actions, to destroying human/nonhuman life? How are these actions specifically suicidal or genocidal? Universities, and to some extent public schools, are still some of the safest places to speak out and take action. Science educators should see political engagement in Freirean terms: as acts of love. They should conversely come to recognize as problematic those who insist on the depoliticization of the educational space.

Transdisciplinarity is a revolution in aesthetic terms. The aesthetic, what can be seen or sensed, serves as the substrate for what is possible. Changing what science education looks like and feels like — that is being aware of the aesthetic dimension — is vital for transforming science education.

III. Matters of concern and their equal importance

⊙ Equality of concerns - Scientists and science educators must increasingly treat the various ethical, ecological, and social concerns people bring to science education and science research with equal value¹³. The reality is these concerns are actually often much more important. The education of scientists and science educators has, historically speaking, generally taught them to disregard anything that doesn't fit within, or can be immediately recognized, by their particular paradigm of science research. This narrow mindedness, created by professionalized cultures that prize short-sighted success above all else, is an outright

¹³ See the insightful work of Isabel Stengers in the manifesto: Isabelle, Stengers. *Another science is possible: A manifesto for slow science*. John Wiley & Sons, 2018. Stenger's work is one of the inspirations for this manifesto, because it 'debunks' the idea that scientists should only value the tiny inner circle that legitimizes what questions are worthy of their attention.

rejection of the very critical attitude science maintains as one of its most prized values. The truth is that, especially in times of right-wing populism, scientists rely on the support and imagination of political activists, artists, and educators of all kinds. It is they who create much of the ethical space for science and science communication in relation to environmental health and wellbeing, the plight of nonhumans, structural racisms and inequalities, differences in sex/gender and sexuality, and the conservation of life or preventing extinction¹⁴.

◊ Living with Disturbance - Educators need to come to terms with the fact that most of their schools and institutions, which includes faculties of education, are not prepared to face the ecological, social, and psychic disturbances that have already arrived. And yet, educators must continue to have faith in, and solidarity with, those institutions that nurture a sharing of what we hold in-common, such as natural environments, scientific knowledge, and the chance to change how we want to ethically live. Disturbance has come to mark life in times of ecological and social precarity, such that sharp disruption to ecological systems and human social life will increasingly be the norm. Hope lies anywhere teachers and students can work alongside their fellow beings to nurture new ethical possibilities and forms of collectivity that arise from various forms of disturbance¹⁵.

◊ Challenging Oppressive Images – The commonsensical outlook of someone engaged in the sciences has historically come from white men with a Global North mindset¹⁶. One of the things politics, as the movement towards equality, does is re-introduce the problem of subjectivity to the sciences. A problem that takes on a particular vibrance in fields obsessed with subjective-objective dualisms (Mathematics is probably more obsessed with objectivity). The oppressive image of a ‘real scientist’ — ‘real researcher’ — ‘real science educator’ has to be let go in order to free ‘science people’ to explore matters of concern and grave importance¹⁷. Challenging these images cannot be relegated to courses that contextualize science (e.g. history of science or science ethics, etc.), it must be done in science courses of study themselves as well as science teacher education. Science research and pedagogy must

¹⁴ These are what Isabel Stengers (2018) calls ‘science connoisseurs’, who aid scientists in their engagement with the public.

¹⁵ Anna Tsing’s work brilliantly examines disturbance as an ecological-anthropological category see Tsing, Anna Lowenhaupt. See *The mushroom at the end of the world: On the possibility of life in capitalist ruins*. Princeton University Press, 2015.

¹⁶ Consider Luce Irigaray’s challenge to image a completely different subject for both science and philosophy: Irigaray, L., & Oberle, E. (1985). Is the subject of science sexed? *Cultural critique*, (1), 73-88.

¹⁷ Science educator Maria Wallace problematizes teachers are brought to being ‘science people’, as both an enabling and disabling process of ‘subjectification’. See Maria FG Wallace. "The paradox of un/making science people: practicing ethico-political hesitations in science education." *Cultural Studies of Science Education* 13.4 (2018): 1049-1060.

move away from lightning fast knowledge mobilization, and toward diverse matters of intimate social and ecological and social concern.

◊ Relationality and Science - Engaging matters of concern in science education involves making intimate relations with others around these matters of concern. Such relations cannot be captured by competition and the narrow mindset of personal advancement. Science educators and students should seek opportunities to create new ethical relationships. Establishing deeper ethical relations would neither affirm nor disavow any sort of a priori academic rigour. Rather, the rigour introduced would be highly variable and ‘muddy’. Instead of always asking what can be abstracted, moved away, and transferred from phenomena and relationships, as is often even the case with science and science education courses, educators might begin asking what can be learned within the rich relations already present, and are yet to come, in the many contexts of science education. This will involve challenging the dominance of various measurements and assessments, which bar students, teachers, and researchers from meaningful relationships with their communities.

IV. Dependence and sociopolitical issues

☞ Stupid Viruses – Science has so much to say about how we live collectively. What science continually makes clear (and not just epidemiology) is that we are, in the end, completely dependent on each other. And what COVID-19 made very apparent is that all of us live in a world where science and objectivity are important ways of understanding the world. This is one ‘good’ realization resulting from the pandemic. On one level, there is no deeper meaning to the virus itself. The virus is just a relatively simplistic arrangement of nucleic acids and proteins. While humans are somewhat powerless in the face viruses, they do have their immanent powers of reason, experimentation, and collective problem solving to employ for the benefit of all. Though right-wing populist forces would attempt to keep science and science education away from collective matters of concern, COVID-19 and other wicked environmental-social problems only thrust science — an ethical, multifaceted, and engaging kind of science — into the forefront. In a strange way, we must give some credit to these viruses that may or may not qualify as fully alive. They have done a lot to make people realize just how integral a *science-with-values* may be to life on the planet. These values cannot be the values of a parochial science. They must be global.

☞ Politics and Dissensus - Part of the challenge of engaging ‘socioscientific’ issues in classrooms today involves recognizing that the actual ‘political machinery’ available to the next generation, like our educational institutions, is just not adequate to the task of facing the

sociopolitical and ecological problems of our current moment¹⁸. Protest is one avenue of engagement, and certainly the “March for Science” in the United States and elsewhere raised awareness of slashed funding for environmental protections and research¹⁹. Aligning with movements like the Indigenous grassroots movement *Idle No More!* can give direction to students looking for more relevant and satisfying ethical commitments and relationships.

However, education is in-turn vitally important to political protest; because demonstrations, or even justified violence, against brutality without political, ideological, or ethical coherence become expressions of a kind of ‘loss of control’. Or even more bizarrely, not taking the issues seriously enough: ‘we don’t know what to think or do, so we’ll break something!’ Science education may be just as vital to political protest, as political protest is for promoting the findings of science. Politics — as a break from the status quo to include those who have not been counted equally — has a naturally affinity for the major ethical projects of science — alternative energy, climate change research, conservation and preservation, trans/gay rights and freedoms, environmental racism and destruction, and even cosmological and Astronomical research for extra-terrestrial life. All of these projects, in one way or another, problematize the hierarchy of some humans (e.g. white, male, heterosexual, middle class, Western), or humans in general (as one problematic species amongst many).

🗺 **Making Maps** – Maps — cognitive, material, ethical, geographic, temporal, historical — are necessary for students and educators to determine what’s possible. Mapping the contexts for science and education requires generative thinking — and necessarily combines any and all materials, relationships, capacities, discourse, and capacities into assemblages of multiplicity. Assemblage thinking through the thought of scholars like Manuel Delanda seeks to literally map or diagram the material-discursive relations between things as seemingly disparate as gender and agriculture in ways that work to enrich both science and education²⁰. Through mapping assemblages, students and teachers can envision where ethico-political possibilities and ‘fault-lines’ exist when it comes to matters of concern. This kind of cartography is expansive and always shifting. Older ‘maps’ don’t get thrown away but can be placed back on a new map or assemblage. Diagramming assemblages of collective existence

¹⁸ It’s important to remember that engaging socioscientific issues must include the political. See Raveendran, Aswathy. Invoking the political in socioscientific issues: A study of Indian students' discussions on commercial surrogacy. *Science Education*. 2020 [Online First].

¹⁹ The importance of protest to science education is always an interesting ‘controversial’ question for my students. See Lowan-Trudeau, Gregory. "Protest as pedagogy: Teaching, learning, and Indigenous environmental movements." (2019). Also, for more of a discussion on politics, dissensus and science education see Bazzul, Jesse. "Towards a politicized notion of citizenship for science education: Engaging the social through dissensus." *Canadian Journal of Science, Mathematics and Technology Education* 15.3 (2015): 221-233.

²⁰ See Jesse Bazzul and Shakhnoza Kayumova’s. Toward a social ontology for science education: Introducing Deleuze and Guattari’s assemblages. *Educational Philosophy and Theory*, 48.3 (2016): 284-299.

should be coupled with matters of concern ‘on the ground’ — in a continual dance between what is materially visible and what can be thought or created in response, or the virtual and the actual.

☞ **Knowledge Commons** – Returning to pandemics as issues for centuries to come, science not only has a role to play in finding vaccines, but in outlining the contours of a diverse and ever-growing commons. The commons are essentially everything that can be shared. Both education and science, ideally conceived and practiced, are powerful forms of the knowledge commons. Vaccines demonstrate how common ‘property’ (it is very easy to see that any vaccine developed must immediately be shared) can be enclosed, privatized, or stolen for the benefit of a select few (e.g. one nation, the rich, etc.). Science educators have a strong stake in building the commons, because communal scientific research can only continue if knowledge is made accessible to all (even just all scientists). A new piece of knowledge is entirely dependent on the rich knowledge commons that gave rise to it. Any attack or exploitation of the commons only weakens our shared commonwealth. The future therefore involves stopping those who would enclose or exploit the commons — not just because it is morally wrong, but because it is anti-thetical and destructive to the growth of shared worlds — which, again, includes science. As science itself teaches, the relationship between commonality and multiplicity is a mutually constitutive one²¹. Science and education as forms of the common(s) are important politically because isolation, self-interest, and an appeal to violent hierarchies is the norm for right-wing populism. The knowledge commons, which belongs to all, must play a guiding role in nurturing collective interests and allowing difference to continually unfold in the world.

V. Objective knowledge and Biopower

Y **Knowledge and (Bio)power** – Objective knowledge has a direct relationship with power in any social field. Although this basic idea is often attributed to poststructuralism, its emergence and critical arguments are more soundly structuralist. There should be nothing controversial about accepting that there’s a relationship between knowledge and power²². Modern governance, since at least the 16th century, has increasingly incorporated techniques of population management that rely on empirical data and objective knowledges to discipline,

²¹ See also Means, Alexander J., Derek R. Ford, and Graham B. Slater, eds. *Educational commons in theory and practice: Global pedagogy and politics*. Springer, 2017.

²² Michel Foucault becomes a very important philosopher here for both education and science. See specifically the essays entitled the “Discourse on Language” and the “Subject and Power”: Michel Foucault. "The Archaeology of Knowledge and the Discourse on Language. 1971." *Trans. AM Sheridan Smith. New York: Pantheon* (1972); and Michel, Foucault. "The subject and power." *Critical inquiry* 8.4 (1982): 777-795.

as well as nurture, bodies. What changes in modernity is that governance happens at both the level of individuals and populations (once the idea of a population or biological *milieu* becomes thinkable). Historically, this has meant that some bodies are made to live while others are purposely punished or left to die (think colonization)²³. This notion of ‘governmentality’ has employed the authority of science, for example the disciplines of biology, geology, and chemistry, to exercise power, or *biopower*.

Y Conducting Conduct – Biopower, in its simplest form, is the exercising of power over life. That is, over populations and individuals simultaneously. It is mainly exercised by *conducting the conduct* of individuals in ways that affirm a particular identity, purpose or ethos (e.g. citizen, healthy individual, sexual being, industrious worker, rational animal, etc.). Objective knowledge, which science purports to be, lends authority to the exercising of power. This is the case whether this knowledge is ‘actually true’ or not. All that is needed is for the knowledge to be ‘considered as truth’ – which does not at all mean that empirically tested scientific knowledge and religious doctrines – both being types of truth – are the same thing.

Y Double-Truth Value – Scientific knowledge disseminated in state-approved curriculum and institutions of schooling therefore has a ‘double-legitimacy’. This is because it has been sanctioned by both a scientific community and the power of the state — two different institutions that today bestow objectivity. Because of this double-legitimacy, science education arguably has more power to shape the ethical conduct of people than other areas of education. Science education’s discourses and practices, again more than other fields, come to bear on questions of collective existence, identity, and ethical conduct — even though science education is still often seen as being ‘value free’. Science educators are situated at an important nexus of power relations; one that is more intensive than in say history or literature. Science education, as a confluence of disciplines, therefore comes to form who students think they are, what they think they should be doing, and their very ethical sense of self or subjectivity²⁴. So, on one hand, science educators are conduits of biopower—wielded through technologies of modern governance that exercises power over life through the conduct of conduct (and this includes nonhuman life). On the other hand, science education is a key point

²³ Again, we have Foucault’s work to make sense of these changes in the way power is exercised alongside knowledge: from sex to ethics to economy. See Michel, Foucault. *The history of sexuality: An introduction*. Vintage, 1990. Also, look at the way Ann Stoler brilliantly takes up Foucault’s basic premises in Ann Stoler’s *Race and the education of desire: Foucault's history of sexuality and the colonial order of things*. Duke University Press, 1995.

²⁴ See for example the way sex/gender roles and expectations are woven into biology curriculum in Aswathy Raveendran’s, and Sugra Chunawala. "Reproducing values: a feminist critique of a higher secondary biology textbook chapter on reproductive health." *Indian Journal of Gender Studies* 22.2 (2015): 194-218.

of reflexive (biopolitical) resistance to this power, where science educators and students recreate and negotiate how they create ethical relations with others, themselves, and the world.

Υ Resistance from Below – The prospect of biopower may seem very daunting, but ultimately the power used to govern ‘from above’ is, in the final analysis, generated ‘from below’. This means that, first and foremost, students and teachers always have the freedom (no matter how small) to resist and be/do otherwise. It is helpful to compare the exercising of power to the flow of electricity, there is always resistance in the circuit beforehand (unless you have a superconductor). Power in a social field cannot be exercised over students unless they have this possibility to resist (otherwise it is total domination and something else altogether). Science educators have the ability to unite and contend with the ubiquitous forces of (bio)power, with the understanding that science is inextricable from how people are brought to conduct themselves and find a sense of self, meaning and purpose in modern times. While science education is integral to the exercising of (bio)power, it is also integral to the biopolitical struggle against undesirable aspects of (bio)power that seek to destroy and control. The responsibility to engage (bio)power is therefore integral to science and science education. And, as mentioned above, engaging with the relationships between knowledge and power means looking outside of science.

VI. Capitalism and Science Education

不 Invasive capital - For science education to work toward sustainable collective futures, it must understand its relationships to capitalism more intricately. Capitalism is not an isolated economic phenomenon. Rather, it has become a dominant form of cultural life, social exchange, and has spread to most parts of the modern imaginary. Geographer Jason Moore has gone as far as saying that capitalism pervades our very view of the ‘web of life’; and that the taken for granted separation between nature on one side, and capitalist economics on the other, greatly underestimates how ecological systems are increasingly cast through a capitalist lens²⁵. Western juridical systems also bestow ownership and reward on those that would make ‘inert’ nature, profitable and ‘active’²⁶. In this sense, the increased burning of rainforests is long-standing colonialism exacerbated by the right-wing; but it is also a latent quality of modern capitalist institutions to ‘make land make money’. Capitalism, along with the rule of private property, stem from those same controlling forces of modernity that gave rise to things

²⁵ See Jason Moore’s *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*. Verso Books, 2015.

²⁶ See Sheila, Jasanoff. "Taking life: Private rights in public nature." *Lively capital: Biotechnologies, ethics, and governance in global markets* (2012): 155-83.

like colonialism and slavery²⁷. Capitalism, colonialism and slavery can be seen as entangled with the systematic deployment of biopower that seeks to manage populations and control conduct.

✘ Corporate Interests – The relationships science and education have with the (re)production of capital are highly relevant to the ethical work science educators do. Why? Because it is the pursuit of capital that is driving very high extinction rates, climate change, the push for resource development, new military technologies, and at the same time, as mentioned above, the obfuscation of science. These relationships involve the way STEM initiatives are interlaced with the corporate sector's goal of engineering low cost human capital for technology industries²⁸. It is also important to understand that the funding of science research is intricately connected to economic competition, changes in the research and development strategies of corporations, and the neoliberal restructuring of universities. An overall theme for educators to explore involves how science funding for research in the public interest competes with the growth of capital.

✘ Impoverishing everything - Resistance to the subordination of both science and education to capital demands an interrogation of not only the purposes of science, but the way knowledge production has been formulated as a field of competition. This audit-culture mentality²⁹ diminishes intellectual and scientific work overall by making it conform to whatever will get it published and disseminated fast. When it comes to knowledge production, educational communities can (and do) conduct their own research and conscientiousness raising. Students and teachers always have at least two basic ethical-political tools at their disposal. The first is dissensus — breaking with the status quo in the name of equality — so that more beings (even nonhumans) can be counted and included equality. Second, and this is an ethical project that demands more attention from the political left, (re)discovering how pleasurable and wonderful reality actually is... outside of capitalism. Capitalism makes everything into commodities, yet hides this fact by making people think these commodities are more than their use value. In a tiny and perverse way, capitalism gets this aspect of reality correct: things are always more than humans think they are. But that's just it. Things are infinitely more than what corporations, media and markets tell us they are. And what better

²⁷ See Hardt and Negri (2000, p. 69).

²⁸ For a closer look at the larger biocapitalist context for schooling, and also STEM education, see Clayton Pierce's. *Education in the age of biocapitalism: Optimizing educational life for a flat world*. Springer, 2012.

²⁹ While I am mostly referring to science publishing, a context of rampant competition, short-term reward and incentivisation is rife in academia in general. See Marc Spooner's: "The deleterious personal and societal effects of the "audit culture" and a domesticated academy: Another way is possible." *International Review of Qualitative Research* 8.2 (2015): 212-228.

endeavour than science and science education to realize this? Where we try our best to look at the world outside of ourselves and our human constructs; yet at the same time gain a world that is intimately of ourselves (worlds that are simultaneously human constructs).

The film industry can imagine the dystopias of capitalism to their finest detail. Why can't it imagine worlds without massive amounts of private wealth or global ecological catastrophe? This is something educators must try and do with their students!

VII. A strange Anthropocenic reality

★ **Anthropocene detonators** – It's true. The planet is 'messed up' in many ways. But not just because humans (again, some more than others) are responsible for precipitating another major extinction. Our current moment, or epoch, of the Anthropocene is one where the geological and biological makeup of earth will be changed for millions of years due to human industrialization, agriculture, resource extraction, and chemical waste. Of course, what constitutes the markers of the Anthropocene is under study and debate³⁰. Anna L. Tsing's transdisciplinary project called *Feral Atlas*, a transdisciplinary conglomerate of scientists, artists, and social scientists studying Anthropocenic environments, refers instead to Anthropocenic *detonators*³¹. These detonators are more transdisciplinary and involve the imagination associated with the humanities and social sciences. They are as follows:

- **Invasion:** The consequences of European invasion of the Americas and the displacement and genocide of human, plant, and animal life.
- **Capital:** The massive increase in exploitation of environments for profit and monetary gain.
- **Acceleration:** The conscious and concerted push to industrialize the entire planet in the twentieth century.

The markers of the Anthropocene are distressing; but the Anthropocene itself also points to some uncanny aspects about the world we share.

★ **Dissolving boundaries** – The Anthropocene has demonstrated that any attempt to maintain sharp dividing lines between what is 'natural' and what is 'social' is not only erroneous, but dangerous. The testing of nuclear weapons, the dispersal of microplastics, and

³⁰ See Lewis, Simon L., and Mark A. Maslin. "Defining the Anthropocene." *Nature*. 519.7542 (2015): 171-180.

³¹ I had the chance to interview Anna Tsing about *Feral Atlas*, as well as insights into education in the Anthropocene. See Anna L. Tsing and Jesse Bazzul. *A Feral Atlas for the Anthropocene: an interview with Anna L. Tsing*. In Maria Wallace, Jesse Bazzul, Marc Higgins, and Sara Tolbert's. *Science Education for the Anthropocene*. Palgrave MacMillan (Forthcoming, 2021).

the displacement of countless species and Indigenous peoples are human social developments. But, they are also geological and biological events. Likewise, the geological alterations to the planet by a single biological species now gives shape to ‘the avante garde’ in art and literature. As it turns out, reality just will not stay inside the boxes modern peoples designate as either ‘cultural’ or ‘natural’. Indigenous education is very helpful in terms of dissolving these boundaries³². While scientists, to their credit, have long understood that the biological is historical, and vice versa, they very often express this fact in the most dogmatic one-sided way possible, by insisting that scientific knowledge is reality, and that social and historical lenses do not matter (or do not matter as much)! Quite the opposite is true in fact. The Anthropocene means that all ways of knowing — the arts, the sciences, theology, agriculture, etc., on some level, come to bear on our shared ecological phenomenon. This means that only a transdisciplinary approach is relevant for science education in the Anthropocene.

★ **Hyperobjects** – Things like the Anthropocene, climate change, and extinctions are what ecological philosopher Timothy Morton calls hyperobjects — objects so large they can only be conceived or observed in parts at one time³³. Hyperobjects are uncanny, and never quite what they seem. This infinite quality is arguably a property of every object — it’s just that with hyperobjects this unknowable quality is more noticeable. For example, it is impossible to behold something like climate change in its entirety. Only changes in ocean pH, or the politics of climate policy, or stories of rising sea levels can really hold our attention at any one time. Anthropocenic reality is therefore ironic in the sense that the more visible human impacts are, the more obscure and elusive our personal existence and sense of purpose becomes. The Anthropocene is a hyperobject precisely because our individual actions both touch it, yet don’t touch it. I know that, as one human being, recycling an aluminium can makes no difference to the future of life on planet earth. And yet, as a human being, purchasing or recycling that same aluminium can is directly related to the future of life on planet earth. Figure that one out!

★ **Real(ity) Pleasure** – Science educators and students need to find ways to embrace the highly pleasurable, obscure and uncertain reality of things. They can do this by nurturing uncertainty and complexity — how no one way of knowing or understanding a thing totally captures it. Ecologists understand this when they fall in love with the living things they’re studying, or when they realize the complete dependence humans have on fungi, emotions, water, skin, connection, microorganisms, etc. What capitalism has done (capitalism being

³² See Gregory, Cajete. *Native science: Natural laws of interdependence*. Clear Light Publications, 2000.

³³ See Timothy Morton’s. *Hyperobjects: Philosophy and Ecology after the End of the World*. U of Minnesota Press, 2013.

another hyperobject), is to reduce the strangeness and infinite complexity of things to what markets and corporations say a thing is — a Brazilian rainforest is timber, pasture, minerals, or wild getaway vacation etc. — when, in reality, the quality of things, and our relations to them, are infinite and always multiple. Teachers and students don't just need to 'get serious' about issues of common concern; they need to realize the pleasure that awaits them outside of the impoverished desire and enjoyment capitalist modernity cultivates.

VIII. Conclusion: nonhuman solidarity and hope in 'the Left'

☞ **Extend Solidarity** – Solidarity isn't some ultra-virtuous act carried out by humans; it's a necessary aspect of the symbiotic real world. There isn't one organism that is not completely dependent on others (nonhuman, nonliving, human, etc.) for life³⁴. This quality of 'relying-on', which is solidarity writ large, is an integral part of ontological reality. This means that to be anything, at any scale, is to be incomplete. Solidarity, therefore, is also infinitely variable, because a thing's infinite variability and co-dependence means new types of mutualistic relationships are always possible. Evolution and human sociality bear this out, because different forms of mutualism and queer relationships inevitably form as both human history and biological evolution unfold. Solidarity therefore needs to be reimagined and extended to nonhumans as a foundational principle, in addition to extending 'human rights'. Today, only Indigenous education allows ample creative space to think about co-dependence and relationships with nonhumans. Modern human societies must examine their 'severing' from closely knit nonhuman relations due to systemic agriculture, human exceptionalism (anthropocentrism), and the pursuit of capital. Science educators must begin to explore the multitude of relationships they have with nonhumans, and simultaneously reject the idea that these rich relations are somehow only for children.

☞ **Outside the human** – If solidarity and co-dependence are ubiquitous it seems very wrong to teach students that the world is made up of independent beings who do things without others every step of the way. Education should veer towards understanding multiple symbiotic relationships, and how 'relying-on things' holds us all together. Making solidarity, as a fundamental aspect of our being, exclusive to humans is effectively an attempt to privatize solidarity. But there is no such thing as a private reality!³⁵ And science teachers, of

³⁴ In his book *Humankind*, Timothy Morton extends solidarity to nonhumans, by showing two things: First, that the flaw in the left is the exclusion of nonhumans. Secondly, by persuasively arguing that solidarity--or relying-on things-- is a ubiquitous aspect of reality. See Timothy Morton's. *Humankind: Solidarity with non-human people*. Verso Books, 2017.

³⁵ See Michael Hardt, and Antonio Negri's. *Commonwealth*. Harvard University Press, 2009.181.

all people, know that, in the end, reality cannot be privatized to one group or type of being³⁶. Alienation from nonhumans is proving to have drastic deleterious effects, and is partly the result of a rejection of heterogeneity and indeterminacy. Restoring solidarity with nonhumans is not only deeply ethical, it also promises to be deeply pleasurable. Interestingly, this is where science, while undoubtedly a human endeavour, is one of the few vantage points where teachers and students can glimpse a world, even if just for a brief moment, outside of human exceptionalism. That is, where the human social world does not necessarily grant any special access to reality – though humans certainly do interact with the world in a way that’s different from other organisms. Solidarity with nonhumans doesn’t require a Marxist education. It requires understanding and exploring how oak trees, clouds, and surfers actually have a lot in common and are completely co-dependent!

♣ **Equality and ‘The Left’**- Educators can trust that, for the most part, left-wing ideas are, for the very small purview of human relations they attempt to explain, ‘generally correct’... in a certain way. They are generally correct in what they say about inequality, both in the human world, and in the way (some) humans have come to dominate all other forms of life. That inequality exists where it shouldn’t exist. Whatever exception conservatives, and also liberals, have about critical theory and forms of collective living they cannot deny the persistent growth of multiple forms of dispossession, dominance, and destruction of life (although they might say something outlandish like: ‘hierarchies are just natural, humans should look to Arthropods’!). In general, left-wing social theories are also correct in their affirmation of equality, and the overwhelming collective desire to live together while nurturing and sharing the commons.

Educators worry too much about neutrality, when education never has been, and never will be, neutral. While education involves many important things, such as knowledge transfer and skills training, it is ethics that lies at the core of the pedagogical act. How? Because education always involves taking someone from one subjective position, one they are attached to in multiple ways, and moving them towards a ‘better’ subjective position. In this way, science education both overtly and covertly shapes a type of ethics and subjectivity in students and teachers. Science education cannot distil this ethical calling down to a simplistic policy or pedagogy precisely because education’s very essence is ethics. And since ethics is the essence of education, it is absolutely anti-thetical to education to ignore issues of sociopolitical and environmental concern in all their complexity. Education today is slowly

³⁶ For a more elaborate discussion on education, solidarity, and ontology see: Bazzul, Jesse. Solidarity with nonhumans as an ontological struggle. *Educational Philosophy and Theory* [Online first]. 2020.

(but surely!) embracing an ethos of sociopolitical and environmental engagement, because the effects of the Anthropocene and their historical precursors are too obvious to ignore.³⁷ Anybody questioning this would now seem to no longer have any serious moral or ethical footing by which to base their arguments. They would have only rhetoric about making the rich richer or recapturing a romanticized hegemonic past. Besides being ridiculous, this rhetoric is simply not viable for life in the coming centuries.

♣ **A new ethics** - The Covid-19 pandemic and the burning of the world's forests simply made the truth that humans are entirely symbiotic and dependent life forms more visible in both painful and constructive ways. This truth means that the future of our species, and countless others, lies in the expansion of relationships and our capacity to share. For science education to be relevant in a post-truth era — with the assault on truth coming from the populist far right-wing — it must enter into intensive relations with other ways of knowing (transdisciplinarity), seriously engage matters of collective concern, and seek to understand its own politics of knowledge. This means that the type of ethical person and the kind of ethical attachments and relationships that science education nurtures will be much more expansive to the point where they may be somewhat unrecognizable to traditional science educators. This shift would mean that science educators are doing something for the collective good, and therefore in the interests of science and the commons.

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³⁷ In science education see Sara Tolbert and Jesse Bazzul's. Toward the sociopolitical in science education. *Cultural Studies of Science Education* 12.2 (2017): 321-330.

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