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**REIMAGINING SCIENCE
AND TECHNOLOGY
EDUCATION IN THE
COVID-19 PORTAL**

JASTE

An open-access, community reviewed, journal prioritizing acts for personal, social and environmental wellbeing regarding science and technology and their educational counterparts.

JOURNAL FOR ACTIVIST SCIENCE & TECHNOLOGY EDUCATION

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Reimagining Science and Technology Education in the COVID-19 Portal

- Edited by Steve Alsop & Larry Bencze

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Editorial: Reimagining Science and Technology Education in the COVID-19 Portal

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JASTE is a non-refereed, open-access, journal. We encourage reader feedback on contributions to it. Please send your comments, suggestions, etc. about this paper to either or both Steve Alsop and Larry Bencze. Thanks!

Introduction

The impact of the COVID-19 pandemic has been swift and savage. So many of us have watched press briefings and news reports as realities unfold and fatality figures rise. This week, the numbers of total confirmed cases approach 10 million and the global deaths are around 500 thousand. Yesterday (June 24th) was one of the largest increases in these figures. What was once a pandemic predominately of rich countries, is now affecting the Global poor. Privileged, wealthy countries have struggled, and are still struggling, with wanting medical infrastructure, absences of basic personal protective equipment (PPE) and testing apparatus. Many frontline care workers, doctors and nurses, have died because of shortages of disposable, basic health kits. The vulnerable, homeless, hungry, sick and elderly have been hard hit. So have Black and Asian people, which some statistics suggest are up to 50% more likely to die from COVID-19. Too many now mourn the loss of family, friends, colleagues and acquaintances. People are struggling to get-by with fiscal insecurities and economic hardships that as White, cis-gender privileged academics we struggle to even imagine. Lockdown is probably the largest standardized policy the world has ever known. It has contained the virus, saved millions of lives, but in so doing it has increased stress, anxieties and trauma. There has been a marked rise in domestic violence and mental illness.

Handwashing, lockdown and social distancing all make assumptions. Over the past few years, I (Alsop) have been working with students and teachers in the Dadaab refugee camps (Kenya) in a higher education initiative (BHER)¹. As the pandemic was unfolding, I spoke with students and they reminded me of the luxury of soap, which many refugee families simply cannot afford (even those working on refugee teacher wages), let alone facemasks. They brought my attention to the impracticalities of social distancing in one of the largest refugee camps in the world, housing over 250 thousand people living in makeshift temporary accommodation for decades. In the camps, 20-30 families share a single water stand and line-up daily for declining food rations. They are deeply concerned about coronavirus, alongside chikungunya, malaria and cholera, all treatable diseases that still take many lives in the camps. I am reminded that there are now

¹ Borderless Higher Education for Refugees. Further details are available: <https://www.bher.org/>

more refugees and displaced people in the world than ever before, and these figures will likely rise as a result of the pandemic.

The brutal murder of George Floyd by Minneapolis police is another world shaking event. This sickening and needless death and many others have led to uprisings in the US by Black Lives Matter (BLM) and those held in solidarity around the world. Protestors, in defiance of lock-down, have brought deeply ingrained injustices home. BLM have reignited and reoriented civil rights movements, bringing attention to racialized injustices, violence and police brutalities. The BLM movement has ruptured civic spheres and injustices that were somehow accepted as a tragic part of everyday life, are now repugnant and indefensible. As JASTE editors and authors, we stand in solidarity with BLM and all those who have taken to the streets in protest. We reflect on ways that science and education practices, including our practices, are deeply implicated in perpetuating anti-Black racism and inequalities. We acknowledge that racism is a public health and environmental issue that is further worsened by the COVID-19 pandemic.

We are all vulnerable to COVID-19 although, in practice, of course, the virus affects different groups in very different ways. The pandemic builds on ingrained inequalities and injustices of racism, colonialism, capitalism, class-struggle, poverty, food and health insecurities and environmental degradations. It is a crisis that builds on crisis. The following articles in this journal issue make this abundantly clear.

The planetary environmental crisis has been somewhat occluded by COVID-19. Buried in the media and news items are conflicting reports of nature flourishing with fauna and flora returning to cities, improving air quality, and greenhouse gas emissions still rising but doing so at reduced rates. Recent news items have marked the last 10 years as the hottest on record, and Siberia is currently grappling with debilitating temperatures and forest fires previously unknown. Indeed, some have asked whether the pandemic should be conceived as dry run — a warm-up act for something much worse. Others have seen it as a moment in which a Green New Deal might be realised.

Around the world, there has been mass closure of institutions of education to restrict the spread of the virus, millions of learners are now out-of-school. UNESCO has been monitoring school closures, highlighting how girls and rural, working class communities have been disproportionately affected. During the pandemic, makeshift educational arrangements have been put in place, mostly in the form of online and distance learning. Students and families lacking computers and stable WIFI connections are further marginalised. In the countries first affected, schools are now reopening. Education administrators, teachers and students are juggling (im)practicalities of social distancing, daily temperature testing, and how best to organise and timetable smaller classes. Teachers are managing unprecedented back-to-school anxieties and uncertainties. This virus is placing a hidden toll on young people and families. Many youth are reluctant to return. Lots have refused.

During lockdown, teachers and administrators have been offering students support and encouragement. We have been worrying about our students and how they are reacting to the circumstances, reaching out and offering compassion and care, sharing anxieties, and working together to make sure that assignments are completed, and courses finalised. We are continuously reminded that emotions and relationships form the basis of every successful classroom. Institutions of education provide support and infrastructures extending way beyond the academic curriculum. These institutions build communities, forge relationship, adding to community resilience and offering hope. Families and students rely on access to school meals, electronic communications and other material resources that schools provide. At York University, for example, over 800 students are reliant on the university food bank. It is important to remember that in lockdown these resources are largely unavailable.

Teachers and students have been working together, supporting each other, sharing anxieties and feelings; listening to each other's stories. Teacher unions, teacher organisations and community groups are working together, mobilizing for change, reaching out to vulnerable communities — LGBTQ2 communities, working class communities, poor communities, black communities, communities of colour and indigenous communities — those often-hardest hit. They have been asking how we might best respond with mutual aid and support. Teachers have real expertise here. They understand and know how to listen to students and have histories of working with communities. This ground-level knowhow is notably absent from high-level government briefings. We are left wondering how centralised policies might have benefited from listening more intently to teachers' and students' local expertise, their networks and mobilisations. We are also keeping a close eye on governmental bailout and the extent to which they go to those in need, rather than the already wealthy and privileged.

The general point is that this pandemic is deeply conflicting and paradoxical. It is terrifying and disturbing and, yet, also potentially liberating. It has exposed the sutures of humanity and ripped these wide-open. COVID-19 makes visible what previously is cast to the shadows, muffled by the cotton wool of privilege and natural orders. Access to science and technology, whether in medical treatments or in classrooms has too often favoured those with particular cultural and economic capital. But, COVID-19 offers opportunities to re-educate, to reflect on what is important, and what needs to change; how can we listen more closely and join in solidarity with others and act. BLM guiding principles and accompanying resources, for example, offer radical bases for re-imagining schools, science and technology education, building on principles of: 1) Restorative justice, 2) Empathy, 3) Loving Engagement, 4) Diversity, 5) Globalism, 6) Queer Affirming 7) Trans Affirming, 8) Collective Value, 9) Intergenerational, 10) Black Families, 11) Black Villages, 12) Unapologetically Black, 13) Black Women (BLM, 2020).

What is undeniable is that, in this pandemic, the profound importance of science and technology education has been in plain sight. Few should now question the need for public engagement in science and technology and the ability to distinguish misinformation and political posturing (including, injecting UV light and disinfectant) from reliable scientific expertise. Viral epidemiology has not been a particularly prominent feature in many school science and technology curriculum. The fallacy of this absence has now been underscored. Many of us have had crash courses on R-numbers, logarithmic growth, and flattening curves, vaccine development, antibodies and herd-immunities, mechanisms of transmission, and the potency of soap and alcohol-based hand-sanitizers. Indeed, there has been a rise in scientific discussion, alongside those family members and friends who espouse proficiencies (sometimes a little too much) in epidemiology, virology, anti-bodies and vaccinations. There has been extended media coverage of scientific methods, the processes of developing and testing vaccination and the painstaking details and timescales entailed. Although we sense a media preference for university scientists solving complex problems, rather than commercialised, for-profit corporations seeking business opportunities and increased shareholder returns.

The point is that scientific knowledge that was once distant and largely invisible, perhaps even too hastily dismissed as irrelevant and esoteric, is now inescapable. Few can now legitimately refute, for example, that science and politics are deeply entwined, constitutive, and inseparable. This is a co-production thesis that so many of us have been arguing (for many years) that should be part of the school curriculum. And many caregivers and parents who have been teaching with much creativity, reliance and fortitude, have re-kindled respect for the considerable expertise and skills of professional teachers. This seems a perfect opportunity to revisit and reform science curricula in schools and universities.

This is not a time for metaphors of conflict, revolution and war (although these have emerged in some political rhetoric). In contrast, we are inspired and energised by Arundhati Roy's invitation to think about the pandemic as "a portal". This metaphor serves to vividly capture the loss of the present, ways in which radical ruptures leave us spinning, oscillating between the past and the present, seeking to make sense of remnants of that which has been lost alongside desires for change. Arundhati Roy (2020, para. 43) captures this all so beautifully:

Whatever it is, coronavirus has made the mighty kneel and brought the world to a halt like nothing else could. Our minds are racing back and forth, longing for a return to "normality", trying to stitch our future to our past and refusing to acknowledge the rupture. But the rupture exists, and in the midst of this terrible despair, it offers us a chance to rethink the doomsday machine we have built for ourselves. For many, nothing could be worse than a return to normal.

The point is that, as teachers and researchers, we can become cocreators in change. If social sciences teach us anything, it is that the future is not predetermined. To return to normal is simple not enough. In walking through the portal, we need to ask ourselves: what is now more visible and how might we appropriately respond? How can we walk with power and resolve, with vision and resilience, joining others including our students, and coming together in progressive alliances for necessary radical changes? It is time to consider what is important in [science and technology] education: what is relevant for people's lives and for planetary wellbeing and survival.

In the following articles you will sense a necessary hesitancy and fluidity of uncertainty, but this accompanies an inspiring and far-reaching progressiveness. Perhaps in this liminal moment, our science and technology education imaginations can break free from reductionist traditions, from market fetishisms, privatisation and high-stakes testing. We should ask ourselves what we need to hold onto and what should we let go. In the portal, Arundhati Roy (2020, last paragraph) invites travelling with light luggage:

We can choose to walk through it, dragging the carcasses of our prejudice and hatred, our avarice, our data banks and dead ideas, our dead rivers and smoky skies behind us. Or we can walk though lightly, with little luggage, ready to imagine an other world. And ready to fight for it.

We would like to thank all the authors involved in this special issue of JASTE. The COVID-19 educational portal is fluid and uncertain. It is destabilizing and demoralising. We respect and thank you for joining with us in this journey, for walking together. We respect your courage and commitments to shape responses, which are frozen in time at particular moment of publication. We acknowledge that most of the articles in this issue were finalised before the murder of George Floyd and therefore pay less attention to this world-changing event than might have been expected.

In assembling this issue, we were sensitive to the pressures of COVID-19 and not adding to already stressful workloads. This issue was not generated by a general call for submissions. The idea was to gather a group of authors as a first stage, offering provocations for what we truly hope are ongoing conversations. We encourage reactions and responses, whether large or small. JASTE is an open-access journal and we include authors contact details on all the submissions.

This issue comprises five articles. In what follows, the authors grapple with how to walk in the portal. Their thoughts and recommendations are truly inspiring and generative. We bring this editorial to a close with brief overviews. Needless to say, the articles far exceed these summaries and, as editors, we encourage you to read the full articles.

[1] Justin Dillon and Lucy Avraamidou — *Toward a Viable Response to COVID-19 from the Science Education Community* — offer delightfully direct system-wide observations and recommendations. They leave the science and technology education community with a single question: what can be done, and

what can be done differently? A “social justice informed approach,” they conclude with a vision for post-pandemic science education based upon recognising and challenging entrenched inequalities. They lament on the invisibility of science education, asking: where is the leadership from scholarship and scholarly professional organisations — such as AERA, EASE, ESERA, NARST and others?

Dillon and Avraamidou frame their response to COVID-19 in the form of seven questions. They reject reductionist curriculum tendencies, exacerbated by PISA, which are simply unable to offer the necessarily guidance and leadership in response to contemporary social and ecological imbalances and injustices. Instead, they propose that the science education community should purposefully re-orientate curricula toward science, environment and health perspectives. They question whether science education research is situated within contemporary socio-political realities and bemoan ways that research still fixates on deficit models of pre-service teachers’ understandings. They invite reflections on the importance of an affective turn in science education, associated with culturally sustainable pedagogies and pedagogies of care.

[2] Ajay Sharma — *Phronetic Science for Wicked Times* — courageously challenges a series of dualistic modernist assumptions and frames COVID-19 as a wicked problem for scientists and policy makers alike. Sharma invites considering COVID-19 as a “dualism-busting assemblage of the *Capitalocene*”, arguing that traditional science and science education are simply not set up to overcome challenges like COVID-19. In response, he advocates abandoning “substantive ontology” and embracing a “posthuman relational ontology”, which prioritises relations over entities and breaks free from commodification for profit. Sharma advocates transdisciplinary approaches to science, including sustainability science and phronetic science. Phronetic science draws on Aristotelian distinctions between episteme, techne and phronesis. The latter denoting practical wisdom and concretely situated judgements

In concluding, Sharma proposes two ways forward. First, he encourages joining with others, sharing and shaping critiques of hegemonic neoliberalism (including ecological modernization and green governmentality). Second, he turns to schools as suitable places to start transforming science, in part because of their emphasis on modernistic dualistic assumptions, but also because they can make a difference. He outlines a pedagogical approach that involves children repeatedly facing ethically fraught situations, experiencing gaps between knowledge and ethically informed actions, while mobilising with others and taking actions. Recent reforms in science and technology education (STSE and SSI) offer a firm starting point for this approach, although these have tended to overlook necessary ethical literacy.

[3] Lyn Carter — *What’s in a Name: Post-liberalism, COVID-19 and Science (Education)* — insightfully deconstructs controversies over the SARS-CoV-2 name and associated forms of disinformation. Her detailed, eloquent scholarly analysis provides insight into “contiguous nature of science and politics” characterised by persistent attacks on the WHO and other controversies surrounding the coronavirus. Carter asks: why are health and scientific organisations being simultaneously valorised and vilified? As we grapple with containing the virus and move forward, this is a fundamental question for science education to consider, especially given its role in educating scientists and medical professionals. A more detailed political discussion of the geopolitical landscape makes this more intelligible. Carter overviews western political positions of liberalism, neoliberalism and post-liberalism and subsequent

rise of right-wing populism (RWP). RWP is evident in recent attacks on leading health and scientific organisations, in which professional technical expertise no longer commands the respect that it once had under liberalism but is now conceived as “service providers akin to any other in market economy”. Trump and other selected political leaders act to systemically undermine regulatory science through disinformation, serving as master ‘bewilderers’ within uncertain, fluid political contexts; risk “Twilight Zones” and Gramscian-type interreganums, in which “the old is dying and the new has yet to be born” (Gramsci).

In concluding, Carter turns to science education offering a series of curriculum possibilities including relevant scientific and technological knowledge and socially acute questions (SAQ) for pedagogical explorations. In response to RWP disdain for science, she advocates for a science education that not only recognises the provisional nature of science but embraces the sociopolitical construction of science. It is no longer tenable to present science as apolitical. Perhaps what is most important of all is the development of resilience, in which actors are secure and confident in technical expertise and can produce risk mitigating actions.

[4] Larry Bencze — *Post-pandemic Science & Technology Education: An Opportune and Necessary Ideological Battle* — firmly situates the pandemic within the crises of capitalism and the struggles for eco-socialist, more just and equitable worlds. These possibilities, he persuasively argues, necessitate radical, paradigmatic shifts in subjectivities and relational meanings and ideological redistributions. Bencze frames the SARS-CoV-2 virus as an ‘instructional packet’ with propagative capacities that enables commonalities to be drawn between the virus and capitalists. Central to Bencze’s analyses is education’s potential role in challenging false consciousness (framed as pro-capitalist dispositifs), through raising critical awareness (conscientização) leading to actions confronting and overcoming hegemonic influences of commodity and value production.

In a progressive and far-reaching analysis, Bencze outlines a particular pedagogical approach to science and technology education, STEPWISE, that builds on apprenticeship design and altruistic values. Bencze recognises the need for honesty about how people are situated but grasps the possibilities of using and redirecting cultural capital for altruistic changes. The educational model is structured in three stages: students reflect, teacher teaches and students practice. Central to this model are student-led ‘research-informed and negotiated action (RiNA) projects. Bencze concludes by reflecting on pedagogical changes, in proposed and actualised forms. He recognises the challenges ahead, but draws inspiration from the teachers and students involved in STEPWISE and recent shifts in research and scholarship, including the upcoming 2021 annual AERA conference, which invites attendees to reject “apolitical stances that limit how our scholarship affects societies”.

[5] Emma McKay — *Luddism, Isolation and Education* — reflects on technology and the pandemic. As a self-identified Neo-Luddite, McKay urges resisting technology at a time at which it seems to have become the substrate of our agencies and sociality. At a time of seclusion and contemplation, McKay advocates a “little methodological Luddism”, in the form of critical attention to the idolatry and mythologization of high-tech and the associated extractive industry. Technology should be understood as a situated and goal orientated tool, judged against core ethical values of purpose, community and conviviality: “what is essential”, “what can we do without?” “How can we get there together”. This self-reflexive approach necessitates a deep re-examination and intimacy, made possible by releasing

dependance of techonology and associated values and joining and creating things together communally. To build a long and lasting world for all involves recognising how dependent we are on each other and the planet and to “go more slowly”. This embraces local collectives, growing community resilience and collectively demanding change.

[6] Steve Alsop and Darren Hoeg — *Collegial Conversations at a Time of COVID-19* — offer a response in the form of collegial conversations — a dialogue of letters. In a series of 4 exchanges (8 letters) over a period of two months as the pandemic unfolds, they discuss changing contexts and ways in which science and technology education might respond. Conversations start by lamenting the academic impulse to frame answers in the form of a COVID-generation, or COVID-society, or COVID education. Instead, they ask: as professional science and technology educators and researchers, what questions might we need now to find our feet again? The emerging exchanges seek to capture the fluidity of collegial conversations as different questions and perspectives emerge. They invite reflection on how to approach and explore ideas in dialogue, ways in which professional conversations stimulate thought and action. Such exchanges are being restricted through lockdown and artificial nature of working online.

Alsop and Hoeg reflect on their White, patriarchal academic privileges, recognising ways in which the pandemic impacts different groups in very different ways. They share teachable moments and curriculum approaches, questioning liberal models of science and technology education and citizenship that offer limited attention to social justice. They respond to the George Floyd killing and the subsequent uprisings and demonstrations in support, and in solidarity with, the BLM movement. As the conversations progress, they attach increasing importance to teachers, students and communities collaboratively fashioning educational responses focusing on, and responding to, injustices related to the global and local differential realities of the pandemic.

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Towards a Viable Response to COVID-19 from the Science Education Community

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Responses

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Abstract. The COVID-19 pandemic has touched almost every corner of the planet and continues to impact on lives, livelihoods, economies and cultures. It is both a human and a global phenomenon. Making sense of what is happening requires an understanding of a number of scientific ideas including viruses, transmission, incubation and vaccination. These are life and death issues and yet the public and their political leaders often display a deliberate mistrust of the science and scientists. How might the science education community respond? We pose a series of questions designed to provoke a strong response to COVID-19 from our community and our colleagues: “How well has the science curriculum prepared the world’s public for COVID-19?”; “How much science education should be online from now on?”; “Are we learning from the current situation?”; “Is science education research producing knowledge that protects society from catastrophic events?”; “How should our working practices change to make science education more resilient, more useful and more transparent?”; “What are the ethics and politics of social distancing and how do they affect science education?”; “What pedagogies might we need to turn to in the future?”; and, “What role should business and industry play in funding science education research and development?” In our attempt to stimulate the development of a vision for science education in the post-pandemic era, we offer initial thoughts about moving forward. What we offer is a departure point, an invitation for the community to engage with pressing issues in science education. The main question we pose is the following: What can be done, and what can be done differently? We envision that this paper will provide some guidance to the readers to re-think the complex systems and socio-political contexts within which people come to learn and practice science and to conceptualize these processes through a social justice lens. We argue that a social justice informed approach towards shaping a vision for science education in the post-pandemic era is of paramount importance and that failure to do so will only serve as a way of perpetuating existing inequalities.

Keywords: COVID-19 • PISA • science curriculum • science education • science | environment | health • science education research • neoliberalism • scientific literacy • trust

Introduction

COVID-19; Coronavirus disease 2019; virus; SARS; pandemic; outbreak; herd immunity; the curve; flatten the curve; asymptomatic; underlying conditions; incubation period; physical distancing; social distancing; self-isolation; isolation; quarantine; lockdown; R-number; behavioural science; personal responsibility; social responsibility; political responsibility; Chinese hoax; fake news; vaccination; anti-vaccination; public engagement with science; distance education; online; virtual learning; video-conferencing; teleconferencing; personal; social; political; national; global. These terms have dominated the media over the past few months. New, technical and often unclear terms make up this glossary, which is currently used by politicians, scientists, journalists, educators, and the general public, to engage in discourses associated with the coronavirus disease 2019 (COVID-19). Some of the terms are used in an ambiguous and interchangeable manner, which serves as evidence of how unclear certain aspects of the pandemic still are. What is clear, however, is that, as a global society, or as a group of interlinked societies, this has not been our finest hour.

Without doubt, many individuals have died who should still be alive and the emotional and financial impact on people's lives is incalculable. We have seen substantial failures of governance, decision making and leadership as well as inspiring and appalling examples of human behaviour. It has become obvious how much more complex than just a health issue the COVID-19 pandemic is. It touches upon all aspects of life and its impacts need to be understood across a wide range of disciplines.

For education in general, and science education in particular, the pandemic has created new realities and raised previously unthinkable challenges. Science and scientists find themselves in the spotlight as both potential saviours or as untrustworthy puppets in ways that would have been unthinkable a year ago. Yet science education and science educators are invisible. So, in this paper, we offer an initial reflection on what all this might mean for the science education community. We begin with a discussion on trust in science and we then raise a series of questions for the science education community.

On Trust

Education is fundamentally a process of trust and science education is no exception. Those of us who have taught in schools have spent countless hours communicating our interpretation of how the world works to hundreds and thousands of children. Implicit in this process is an assumption that, in general, young people believe what their teachers tell them. In reality, science teachers offer little by way of evidence to students to support all the facts that will later be tested throughout their education. Quite often, school science emphasizes the facts of science while the processes of science resemble a "black box". Students are rarely taught about the processes of scientific research even though it is these processes that might save millions of lives. What scientists do, what kinds of data they collect and how they analyze those data to form conclusions, remain a mystery for most young people.

Part of the problem is that science deals with things that can't be seen and ideas that are often incredibly sophisticated. Science in school is presented as a straight-forward, logical, empirical and reliable enterprise carried out by highly trained and trustworthy people. While the truth is that picture is some distance from reality, most students believe it sufficiently to make science teachers' jobs relatively straightforward. As a result, public trust in scientists is relatively high. For example, the Pew Research Center survey last year found that '35% of [US] Americans say they have a great deal of confidence in scientists, up 14 percentage points from 2016' (Funk et al., 2019). Another 51% had 'a fair amount' of

confidence in scientists. Hardly the most encouraging figures but much higher than ‘the news media, business leaders and elected officials’ (Funk et al., 2019).

Although research shows that the public has high trust and confidence in science and believes that science provides great benefits to the world, many people continue to deny the conclusions of science in areas such as evolution, climate change and vaccination. Why do people refuse to accept the scientific consensus on these topics despite their high confidence in science generally? Research has shown a link between political convictions and acceptance of climate change science (Motta et al., 2019) but why this is the case is still rather unclear (Druckman & McGrath, 2019). At times like this, the call for science communication and public engagement with science becomes perhaps more important than ever before especially when ill-informed ideologies and anti-science discourses are on the rise.

Social media has allowed conspiracy theorists a platform for a wide range of improbable and impossible ideas:

... belief in the moon-hoax conspiracy has blossomed since 1969. Among 9/11 truthers, anti-vaxxers, chemtrailers, flat-Earthers, Holocaust deniers and Sandy Hook conspiracists, the idea that the moon landings were faked isn’t even a source of anger any more – it is just a given fact. (Godwin, 2019)

Whether anti-vaxxers will be equally resolute in rejecting the COVID-19 vaccine, whenever it is ready, remains to be seen. Most people, for obvious reasons, are relatively unaware of the science behind vaccines when they are given them as a child. When faced with a choice to take a vaccine that could save your life, your parents’ lives and your children’s lives, we suspect that most people will take it — and that will be a giant teachable moment that science education needs to exploit. But is the science education community ready to respond?

Towards a Response to COVID-19 from the Science Education Community

So far, the science education community has responded to the pandemic in three main ways. Firstly, conferences and seminars have been cancelled or moved online. Both cancellations and virtual versions of conferences and seminars come with certain limitations, including questions of whether or not they are equitable practices.

Secondly, some journals have put out calls for papers (as has *JASTE*). The usefulness of these is still to be justified with the kind of engagement and translation of theoretical ideas into practice. While the logic of responding in this way is obvious, perhaps it smacks too much of a “business as usual” approach?

Thirdly, much science education has gone online, whether it be at school level, college level or pre-service teacher level. The question is whether school systems and universities in all countries were adequately equipped to do that, in terms of access to technology, the technological tools available, as well as the curriculum. A more crucial question is whether teachers and lecturers have the knowledge and skills needed to engage effectively in distance education and to implement pedagogies of care, and attend to students’ affective needs during the pandemic. The plethora of terms used interchangeably, such as distance education, e-learning, blended learning, online learning, online teaching, remote teaching, virtual learning, serves to showcase at least a misunderstanding of the role of information and communication technology in higher education.

These three different practices provide an overview of the kinds of reactive practices of the community. What is missing, however, is a response to the pandemic which entails some inspiration, some leadership, some vision statement from organisations such as ASERA, EASE, ESERA, NARST and

others. There are some obvious questions that the science education community might benefit from addressing.

1. How well has the science curriculum prepared the world's public for COVID-19?

Despite strongly advocating scientific literacy for decades, it is clear that far too many of the public are not, however you conceptualise the term, functionally scientifically literate. This science illiteracy is not limited to those with little education — it is also well-established in politicians, policy-makers and business leaders.

We believe that international tests, and PISA, in particular, have failed to provide adequate information about scientific literacy in any useful shape or form. Their influence has not led to the betterment of society; indeed, they have forced many school systems to adopt reductionist curricula and a narrow range of pedagogies. We believe that now is the time for all members of the science education community to withdraw from any involvement in PISA. More importantly, we believe that the science curriculum should be reoriented towards a science|environment|health perspective as advocated by Zeyer and Dillon (2019) and others.

2. How much science education should be online from now on? Are we learning from the current situation?

The current situation suggests that schools' prime role is to allow parents and carers to go to work in order to sustain an increasingly fragile economy. Imagine if we face another pandemic in a few years? Are we searching for innovative and sustainable solutions for science education and schooling? We need to be in a position to switch to an accessible, inclusive, equitable and engaging science education online with support for parents and carers quickly. At the moment we do not seem to be learning anything systematically about what works in terms of taking schools online.

3. Is science education research producing knowledge that protects society from catastrophic events?

Researchers need to use these moments to reflect on their contribution to both the current situation and to the future. Arguments that funders drive research only go so far. Is current science education research situated within contemporary socio-political realities? Do we really need another study that pre-service teachers don't know much about anything? Do we need yet more evidence that children's drawings of scientists reflect societal stereotypes? Effective research with a focus on social justice does not always need to be expensive and we suspect that in the light of the pandemic, funders will be taking a radical look at what gets funded in the future so we will need to adopt our practices accordingly and look elsewhere for support for research that addresses society's needs.

4. How should our working practices change to make science education more resilient, more useful and more transparent?

Can we get by with fewer conferences? Would it hurt if annual conferences moved to biennial events? Do we need expensive venues in expensive cities? Could we reconceptualise conferences as practices of giving back to communities and supporting local economies instead of large corporations?

5. What are the ethics and politics of social distancing and how do they affect science education?

Unquestionably, the scientific basis for social distancing is robust; however, there are various ethical considerations that ought to be examined as well. In essence, social distancing is a process of boundary maintenance and which separates the population into 'us' and 'them'. Science and education, as cultural worlds, are no exception. One ethical consideration is whether social distancing is a Western, colonial construct more easily applicable in individualistic societies and completely ignoring the social premises of collectivistic societies and Indigenous communities. Another ethical consideration has to do with the risks of job loss and reduced income which affects the most disadvantaged and vulnerable populations. An intersectionality lens to examine the ethics and politics of social distancing, which are inevitably connected to science education, is crucial to informing equitable educational policies.

6. What pedagogies might we need to turn to in the future?

The pandemic has brought to the surface persisting structural inequalities that demand new ways of being in the world that centres on 'affect' instead of on 'success'. Researchers in education have called for an affective turn in education that places pedagogies of care and affect at the centre for several years now, in response to the fact that many countries, especially in the West have adopted neoliberal ideologies as the basis for reform in their educational systems. Neoliberalism is found within efforts for privatization and marketization of education, the globalization of a colonial curriculum, the rise of standardised testing, accountability, and competition — essentially, the creation of a capitalist school. What might a focus on affect or the adoption of culturally sustainable pedagogies and pedagogies of care in science education look like in practice? Such an affective turn requires engagement with questions such as: 'How do *all* children enter into positive relationships with science learning?', and, 'How could science education be made more affective and culturally relevant to become more equitable?'

7. What role should business and industry play in funding science education research and development?

Historically, educational research has been funded through governments, a trend that has started to change in the last decade, at least in the West. We have witnessed greater interest from the private sector in educational research. Being forced to explore the potential of various technologies and digital tools for teaching and learning, might serve as an awakening to the possibilities of the private sector and industry in sponsoring educational research and forming of industry-university coalitions. If so, what role is envisioned for the business and industry to play in shaping educational reform? We are aware of the potential risks to researchers' freedom of expression here.

Towards a Vision for Science Education in the Post-pandemic Era

In thinking about a vision for science education in the post-pandemic era, we have raised a series of questions and offered initial thoughts about moving forward. We do not claim to know how the pandemic will shape science education or that we have solutions to pressing educational problems. This paper is simply an attempt to offer a departure point, an invitation for the science education community to engage with pressing issues in the field. The main question we pose for the community is the following: What can be done, and what can be done *differently*?

We envision that this paper will provide some guidance to the readers to re-think the complex systems and socio-political contexts within which people come to learn and practice science and to conceptualize these processes through a social justice lens. We argue that a social justice informed approach towards shaping a vision for science education in the post-pandemic era is of paramount importance and that failure to do so will only serve as a way of perpetuating existing inequalities.

We hope that this paper will provide the basis for conversations aligned with the inseparability of science education and social justice, especially in times like this, and move the field forward in directions that examine ways of using the crisis as an opportunity for a critical transformation.

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Phronetic Science for Wicked Times

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Responses

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Abstract. COVID-19 is a global assemblage that presents a wicked problem for scientists and policymakers alike. Wicked problems that defy easy characterization and solutions are expected to proliferate in the Capitalocene. In this essay, I argue that traditional science cannot be expected to help us understand and resolve wicked problems like COVID-19. Rather, we need phronetic science that is transdisciplinary, ethically aware and oriented towards inculcating practical wisdom in its practitioners. Further, if we wish to see phronetic science being used in tackling wicked problems, science educators can contribute by teaching phronetic science in our schools.

Keywords: phronesis • COVID-19 • wicked problems • assemblage • ethical literacy • science education

Introduction

Intellectual thought of the modern age is defined by repeated efforts to discursively reconstruct our world through an overlapping series of dualisms, such as nature/society, mind/body, real/symbolic, presence/absence, male/female, and civilized /savage (Pickering, 2010). These binaries continue to dominate academic as well as lay discourses in the Western world. However, recent history of the planet has thrown up multiple reminders that modernist dualist logic has outlived its usefulness in making sense of life in the 21st century (Latour, 2012). That is, it has become increasingly difficult to ignore the presence of entities around us that resist being categorized under any dualist ontology¹. As I explain ahead, COVID-19 is one such entity. In this essay, I present COVID-19 as a dualism-busting assemblage of the *Capitalocene* that presents a wicked problem for the humanity. Wicked problems like COVID-19 are only expected to proliferate in the Capitalocene, where it is “easier for most people to imagine the end of the planet than to imagine the end of capitalism” (Debney, 2019; para 2). Traditional science does not appear up to the task for understanding and overcoming challenges like COVID-19. Instead, as I argue in this paper, we need *phronetic* science for such wicked times. And if so, it stands to reason that traditional school science should make way for phronetic school science in science classrooms as well.

¹ In recent years Cartesian dualisms have also earned bad press on account of their role in legitimizing commodification of nature, and oppression of women, colonial populations, and peoples of color (Moore, 2016).

COVID-19 as an Assemblage

In a just published materialist analysis of the COVID pandemic, Nick Fox (2020) traced the evolution of the disease. He found that “the ultimate cause of the epidemic is not the coronavirus particle, but the concentrated centers of population, the global market and the contemporary system of international trade within which humans across the planet now live out our lives” (para 3). That is, commodified interactions between humans and nonhumans embedded in a globalized movement of goods and humans fueled and sustained by global capitalism caused the transmutation of a localized outbreak into a global pandemic. Fox, therefore, labeled COVID-19 as an “epidemic assemblage” that comprises both human and nonhuman elements, and thus can’t be understood within a nature/society dualist ontology. As Levi Bryant (2009) articulated in his blog post, “Assemblages are composed of heterogeneous elements or objects that enter into relations with one another. These objects are not all of the same type. Thus you have physical objects, happenings, events, and so on, but you also have signs, utterances, and so on” (para 9). Assemblages beckon us to understand our world through a different set of metaphors, such as mosaic, patchwork, heterogeneity, fluidity and transitory configuration (Little, 2012). An assemblage’s only unity is that it co-functions together with some sense of shared purpose (Deleuze & Parnet, 1987). As we look around, we can indeed see our world as populated by contingently emerging assemblages that consist of heterogenous components that work together for a limited time before morphing into other or becoming parts of other assemblages. For example, just like COVID-19, the efforts to combat it has also taken shape as a vast crisscrossing global assemblage consisting of patients, bats, markets, doctors, hospitals, governments, and so on. This assemblage will dissolve and/or morph into another assemblage as soon as the COVID-19 crisis blows over.

Taking a slightly different approach from Fox (2020), André Lemos (2020) analyzed the COVID-19 virus from a neomaterialist perspective, as a *natureculture* that straddles the nature/society binary (Haraway, 2007). He found that the virus and the associated pandemic constitute a “virus assemblage” that is produced in the fluxos da globalização e na interrelação entre humanos e animais, mas também nos laboratórios de pesquisa que dão nome e instituem a sua ontologia, nas políticas públicas que produzem ações concretas, na guerra das imagens e discursos escolhidos e veiculados nas mídias, na escolha por formas de prevenção e tratamento médico, na definição epidemiológica sobre a situação... (para 10). (Google translation: flows of globalization and in the interrelation between humans and animals, but also in the research laboratories that give their name and institute their ontology, in public policies that produce concrete actions, in the war of images and speeches chosen and broadcast in the media, in the choice of forms of prevention and medical treatment, in the epidemiological definition of the situation ...).

Lemos’s paper helps us appreciate the important role of the discourses, semiotic resources and the nodal centers that generate and circulate them, such a news media, in the global assemblages that structure our lives in the Capitalocene. For instance, it would be difficult to understand the epidemiology of COVID-19 in the United States without taking into account the role that conservative news media has played in shaping people’s behavior and states’ responses to the crisis.

Taken together, both Fox’s and Lemos’s analyses of assemblages invite us to abandon the *substantivist* ontology that defines the modern intellectual thought. Rather, we are encouraged to view COVID-19 through a *posthuman relational* ontology that decenters humans, privileges relations over entities and places everything — human, nonhuman and discursive — at the same ontological level. Then, we can better understand

COVID-19 as a complex global assemblage of relations and entanglements involving local and distant human, non-human, material, social and cultural actors, and ethical-political dimensions. This overlapping network of relations is neither stable nor fixed. As a result, COVID-19 has proven to be a wickedly complex issue to understand and respond to for researchers and policymakers alike.

COVID-19 Assemblage as a Wicked Problem

Unfortunately for us, it so happens that our current epoch of the Capitalocene teems with wicked problems, like COVID-19. In academese, wicked problems are understood as social policy problems that are defined by high complexity, uncertainty, and contested social values (Rittel & Webber, 1973). These problems cannot be satisfactorily or definitively defined. In fact, wicked problems are “often characterized by multiple conflicting and equally valid scientific and social interpretations” (Miler, 2013, p. 279). The solutions to these problems can’t be categorized as true-or-false, but only as good-or-bad and lack any immediate or ultimate tests for the solutions. Further, wicked problems are intrinsically laced with contested social values and, thus, often present vexing ethical dilemmas. As a result, wicked problems are much different from the “tame” problems of the natural sciences, “which are definable and separable and may have solutions that are findable” (Rittel & Webber, 1973, p. 160). Thus, such problems can rarely be addressed by conceptual and methodological tools and resources available in any single discipline, and call for an ethically informed, transdisciplinary approach.

Most socio-ecological problems are wicked problems because they emerge from “the functioning and evolution of interconnected and complexly interacting socio-ecological systems”, and defy solutions because “they are multicausal, intertwined with other problems, and value-laden” (Metzger & Curren, 2017, p. 94). COVID-19 assemblage emerged when the COVID virus jumped across species barrier to infect humans on a global scale. This barrier crossing happened because of commodified human-nonhuman interactions embedded in a global hyper-capitalist social order that spans, expropriate and commodify all socio-ecological systems. There is little clarity about many critical aspects of the COVID-19 assemblage, and lack of agreement about what would be the best ways of overcoming it. For example, not only do we not know how would the seasonal changes impact the spread of the disease, it is also very difficult to predict how individuals and communities will respond to governmental efforts and regulations in different parts of the world. Further, this crisis poses unique ethical dilemmas as policymakers and laypersons alike wrestle with how best to thread the needle between saving lives and saving livelihoods amidst inadequate public health infrastructure and lack of effective treatments. Not surprisingly, therefore, different countries are trying a wide diversity of approaches to combat this pandemic. Thus, an amorphous, open-ended, constantly evolving and binary-busting natureculture assemblage like COVID-19 can be fairly characterized as a quintessential wicked socioecological problem.

Phronetic Science for Wicked Times

As suggested earlier, COVID-19 is not the only wicked problem that confronts us in the Capitalocene. Environmental scientists now recognize all socioenvironmental issues as wicked problems (Miller, 2013).

Hypercapitalism has led to an unending proliferation of global assemblages “comprising ‘global’ organs, networks of brokers and dealers, donors and recipients, sellers and buyers, who interact in various moral and money economies, and through various forms of technical and political regulation” (Collier, 2006, p. 400). These assemblages work to commodify all aspects of our socioecological world for profit and with terrifying consequences for the marginalized populations, other species and future generations. For example, food production systems comprise a big category of global assemblages that pose a particularly wicked problem of food security and sustainability for food policymakers (Peters & Pierre, 2014). Similarly, the global fossil fuel industry assemblage can be seen as the prime suspect in engendering energy security in the era of climate change, and as another wicked problem that has confounded governments all over the world (Chester, 2009).

In the past couple of decades scientists have begun to realize that traditional ecological approaches that take the nature/society as a given may be fast outliving their usefulness in understanding our world (Bradshaw & Bekoff, 2001). Thus, it has become increasingly clear that traditional science approaches will not be enough to help us understand and resolve these wicked problems (Hart & Bell, 2013). Not only such approaches reify the nature/society dualism, and thus are inadequate at understanding wicked natureculture assemblages, such as COVID-19. They, at best, can only offer technical instrumental solutions that do little to address the deeply entangled social and ethical components of the wicked socioecological problems. For instance, it is now accepted within the scientific community that science alone will not be able to rescue our planet from the scourge of global climate change (Intergovernmental Panel on Climate Change, 2014). Unfortunately, however, the dominance of technocratic discourse in US public policymaking has worked to marginalize the nonscientific dimensions of wicked problems in policy decisions (Lemke, 2005). This has led to depoliticization of socioecological issues as they are reduced to technical problems to be solved by experts. We see this particularly in the case of environmental issues, such as global climate change (Taylor, 2013). Depoliticization excludes citizens and affected populations from decision making with usually terrible consequences for those who are unable to find a designated role in the global capitalist production and consumption system.

Thus, for things to change for the better traditional disciplinary science focused technocratic discourse has to lose its dominance among scientists and policymakers alike. We can begin by prioritizing transdisciplinary approaches, such as those of sustainability science, to better understand and resolve wicked problems like COVID-19. This is because sustainability science is a transdisciplinary field of research that deals “with the interactions between natural and social systems, and with how those interactions affect the challenge of sustainability: meeting the needs of present and future generations while substantially reducing poverty and conserving the planet's life support systems” (“Sustainability Science”, n.d.). Fortunately, in recent years sustainability science and other transdisciplinary approaches have indeed come to the forefront as offering better ways to understand wicked socioecological issues (Hart & Bell, 2013).

But, transdisciplinary science alone may not be enough. This is because, as indicated earlier, all wicked problems are also necessarily ethical problems. That is, in addition to understanding the wicked issues from a transdisciplinary perspective, we also need to make difficult ethical decisions regarding what is the right thing to do when multiple stakeholders press their case backed by different and contesting objectives, claims and sociocultural values. Further, in our decision making we also need to include marginalized stakeholders that are unable to or cannot speak for themselves, such as indigenous populations, nonhuman species and future

generations. Thus, I am increasingly of the view that we need a new kind of science to understand and resolve wicked problems like COVID-19 in the Capitalocene.

If we go by Aristotle's classification of knowledge in the *Nicomachean Ethics*, it can be said that on the whole science has proved to be remarkably successful at developing universal, context independent and analytic rationality-based knowledge systems (*episteme*). It has also excelled at offering practical, context-dependent and instrumental rationality guided technical solutions of problems or knowhow (*technē*) about the world (Flyvbjerg, 2001). Where it has failed has been in developing *phronesis*; i.e., practical wisdom that manifests itself in "the kind of prudential judgement by which equivocal circumstances are negotiated and acted upon with a view for the common good" (Chia, 2016, p. xv). As a morally guided and praxis-oriented form of knowledge, *phronesis* is characterized by

its irreducibly experiential nature, its nonconfinement to generalised propositional knowledge, its entanglement (beyond mere knowledge) with character, its need to embrace the particulars of relevant action-situations within its grasp of universals, and its ability to engage in the kind of deliberative process that can yield concrete, context-sensitive judgements (Dunne, 2005, pp. 375-376).

Given that wicked problems are marked by value-laden moral predicaments that are impervious to both *episteme* and *technē*, it is clear that if we are to survive the Capitalocene we need to collectively position *phronesis* as a primary end-goal of science.

Such a phronetic science would be transdisciplinary as well as ethically informed. By balancing instrumental rationality with value rationality it will be a science directly oriented towards the public good rather than capitalism fueled destruction of the planet. Further, I am of the view that phronetic science for the Capitalocene epoch would eschew modern ethical frameworks of the West, such as consequentialism and deontology, in recommending ethically justifiable actions. These frameworks suffer from the same intellectual and moral conceit that inflicted modern Western thought. For instance, they are: (a) rooted in human exceptionalism that naturalizes nature/social dualism; (b) reify humans as autonomous, rational, responsibilized individuals in full control over their ethical agency; (c) follow a material essentialism that marks entities with "a set of immutable properties that are relatively or absolutely autonomous from those of other entities and relatively enduring" (Castree, 2003, p. 4); (d) are anthropocentric, as they assume "capacity for reason as the definitive basis of a distinctively human ethical standing" (Whatmore, 1997, p. 38) and, therefore, deprive the nonhuman world of any independent ethical status and visibility in ethical decision making; and, finally, (e) work to depoliticize socioecological ethical dilemmas by reducing ethical decision making to following of rules and norms. Not surprisingly, therefore, modern ethical frameworks have been accused of being complicit in legitimizing much of the terrors and depredations of colonialism and Western notions of development (Bauman, 1994).

Thus, I would argue that phronetic science suited for the Capitalocene should embrace ethical frameworks that are rooted in relational postmodern and posthumanist ontologies built on "webs of connectivity between the livelihood practices and cultural values of particularly situated human actors (collective and individual) and the life-habits and relationships of other biotic agents" (Whatmore, 1997, p. 45). By jettisoning nature/society and other binaries, ethical perspectives based on such relational ontologies will encourage us to see our socioecological world as comprising overlapping networks of natureculture collectives (Latour, 2012). Further, nonhumans in these natureculture collectives or assemblages will have their own independent ethical standing. Thus, we will extend just and equitable ethical obligations to them just as they are naturally assigned to the

humans. Finally, as COVID-19 pandemic has made it abundantly clear, it is not unusual for the nature-culture assemblages in today's globalized, hyper-capitalist world to spread far and wide transcending political and geographical boundaries. Thus, to overcome COVID-19 and other socioecological crises of the Capitalocene, we need a phronetic science with ethical commitments that go beyond our geographically localized communities (neighborhood, city, nation-state, etc.) to cover all humans and nonhumans members of the local and global natureculture assemblages that we find ourselves embedded in.

Coda

Given the dominance of neoliberal discourses and hypercapitalism in these dire times, mere advocacy for a societal paradigm shift towards phronetic science perhaps may not work. But there are a few things that we all can do. First, we can begin by contributing to existing critiques of the hegemony of neoliberalism and allied discourses, such as ecological modernization and green governmentality, and circulating these critiques in professional and community networks we are embedded in. Further, I believe that formal and informal science learning spaces can be good places to start work on bringing about a societal paradigm shift that replaces technocratic science with phronetic science as the critical resource for understanding and tackling COVID-19 like wicked problems.

This is because of two reasons. First, there exists a deeply entrenched *Dominant Social Paradigm* in Western industrialized societies that reifies among people a nature/social dualist ontology, low evaluation of nature for its own sake, untrammelled belief in human technological inventiveness in overcoming limitations to human progress and economic growth, and an unfounded belief that modern society, culture, and politics are basically okay (Harper & Snowden, 2017). Admittedly, formal education constitutes only one among a plethora of sources instrumental in shaping our students' orientation towards and understanding of our socioecological world (Weaver, 2002). But, it is one space where we as science educators can make a difference. More importantly, we need a receptive public to support phronetic science as the basis for resolving wicked socioecological issues facing our planet and supply scientists and policymakers who can practice it. Schools are critical institutions where such foundational work can be undertaken. After all, students will perhaps need several years of sustained exposure to transdisciplinary perspectives and ethically informed action before they can grow up as agentive citizens who can challenge and replace the *Dominant Social Paradigm* with more hopeful frameworks, and also appreciate the 'wicked' nature of socioecological issues facing our planet. Thus, if we wish to replace technocratic science with phronetic science as the key policy resource and perspective for such problems, we need to begin teaching phronetic science in our schools as well.

Second, Phronesis cannot be viewed in instrumental-rational terms "as a "resource" or even as a form of "useful" knowledge that can be purposefully deployed in output-oriented, productive action (poiêsis) and/or for personal gain" (Chia, Holt & Yuan, 2013, p. 53). That is, it cannot be grasped directly like one acquires knowledge or skill. Rather, as a habituated disposition phronesis is cultivated over time in the course of repeatedly facing ethically fraught situations filled with ambiguity and uncertainty where no amount of knowledge can tell a person exactly what needs to be done for taking an ethically just action. There will always be a gap between knowledge and an ethically informed action (Fagan, 2013). Phronesis cultivated over time can offer insights into how this gap can be traversed. With sustained praxis, phronesis can become a "part of

the way that one goes about everyday life” (Noel, 1999, p. 284), and gets “associated with what a phronimos does” (Chia, Holt & Yuan, 2013, p. 57). In my view, the kind of indirect knowing that is needed to inculcate phronesis through praxis over time can be best organized in school settings through sustained exposure of students to the challenges of understanding and acting on wicked socioecological problems of the Capitalocene.

Fortunately, there has already been some progress that we can build upon. Science and environmental education community has been cognizant of the need to respond to the socioecological challenges of the Capitalocene. Thus, over time, a strong body of knowledge, practices and curriculum material have emerged on issues and topics related to environmental science and ecology (Hart, 2010). Scholarship on Socio-scientific Issues (SSI) and Science-Technology-Society-Environment Education (STSE) research has also helped educators and researchers better understand how to enable students to appropriate scientific literacy for informed action on science-society issues most of which indeed pose wicked problems for us to resolve (Pedretti & Nazir, 2011). Unfortunately, barring a few notable exceptions, such as Bazzul (2018), Blades (2006), Palmer (2013) and Saunders and Rennie (2013), there has not been much enthusiasm among US and Canadian science education communities for inclusion of ethical literacy as an integral part of science education. That needs to change. COVID-19 is a grim reminder that our world is only going to get more wicked with each passing year. If we start soon, phronetic science may still be able to save us in these wicked times.

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What's in a Name

Post-liberalism, COVID-19 and Science (Education)

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Responses

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Abstract. This paper argues that the coterminous trends of post-liberalism's shifting global power relations and right wing populism (RWP) have been apparent in the persistent attacks on the World Health Organisation, controversies over the SARS-CoV-2 name, and other forms of disinformation during the current pandemic. Scientific expertise and technocratic knowledge have been diminished in a cacophony of political blaming and posturing, exposing once again the entangled nature of science and politics. It is critical for science education to consider this perspective given its central role in the production of future science and medical professionals able to navigate highly charged and contested political spaces.

Keywords: COVID-19 • WHO • experts • post-liberalism • neoliberalism • science education • right wing populism

What's in a name? that which we call a rose
By any other name would smell as sweet.
(William Shakespeare, *Romeo and Juliet*, 1595)

The old is dying and the new is yet to be born.
(Gramsci, 1930).

Names and Naming

One of the images that I have found most telling during this pandemic was of Donald Trump's notes for his coronavirus task force press conference of March 19th, 2020 with the word 'corona' crossed out and replaced with the word 'Chinese.' Trump's increasingly anti-Chinese rhetoric was subsequently amplified by various media outlets including Fox News and the far right Epoch Times, employing terms like the 'Wuhan virus' and the 'CCP (Chinese Communist Party) virus.' A few days after Trump's address, the G7 foreign ministers' meeting on March 25th, 2020 failed to agree to a joint communiqué owing to the US State Department's pressure to include the phrase 'Wuhan virus,' and statements blaming China for the pandemic's spread. Taking it further, on April 13th, 2020, Trump announced the suspension of US funding to the World Health Organisation (WHO) for being "very China centric," and "for severely mismanaging and covering up the spread of the coronavirus."

Trump's vilification of China's pandemic response exists within the geopolitical context of the Sino-US struggle for economic and technological dominance, and the retreat of liberal democracy, sometimes referenced as post-liberalism (see Barrinh & Renard, 2020). It also serves domestically to distract from criticism of his crisis leadership. Nancy Pelosi (Speaker of the House of Representatives, leading Democrat and Trump opponent), in an April 14th, 2020 press release, characterised Trump as "a weak person, a poor leader, [who] takes no responsibility. A weak person blames others. The truth is, from this moment on, Americans must ignore lies and start to listen to scientists and other respected professionals." Internationally, Trump's characterisation of the virus and attacks on the WHO have been widely condemned. G7/20 members, Germany's Chancellor Angela Merkel, France's President Emmanuel Macron and Canadian Prime Minister, Justin Trudeau, as well as Microsoft magnate Bill Gates, former WHO Director General Gro Harlem Brundtland, Editor-in-Chief of *The Lancet* Richard Horton and many others, have argued that the WHO is foundational to a coordinated and collaborative global pandemic response. In no way dissuaded, the US thwarted the call to strengthen the WHO's coordinating mandate at the G20 health leaders' meeting on April 19th, 2020.

So what's in a name when it comes to the virus? And what's the role of the naming institution? Well, arguably more than Shakespeare's Romeo may have thought! On February 11th, 2020, the WHO officially named the virus Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) causing coronavirus disease (COVID-19) in conjunction with the International Committee on Taxonomy of Viruses (ICTV), following guidelines previously developed with the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization of the United Nations (FAO). The name was chosen because the virus is genetically related to the coronavirus responsible for the SARS outbreak of 2003. Sensitive to the difficulties of naming pathogens, in 2015 the WHO issued a set of best practices for the appellation of new infectious diseases. Paraphrased from the WHO's website, the guidelines discourage nomenclature based on geographic locations (Spanish influenza, Japanese encephalitis or indeed, the 'Wuhan virus'), proper names (Creutzfeldt-Jakob disease), species of animals and food (monkeypox), or cultural and occupational references (Legionnaires' disease). Also inappropriate are terms like "unknown," "fatal," or "epidemic" that could unnecessarily incite fear (WHO, n.d.).

As a positive-stranded RNA virus, viral taxonomy places SARS-CoV-2 within the realm Riboviria, the order Nidovirales, the Coronaviridae family (viruses with a crown-like appearance due to the presence of spike glycoproteins on the envelope after the Latin term for crown: coronam), and the subfamily Orthocoronavirinae, which in turn, is classified into four genera of coronavirus: Alphacoronavirus (alphaCoV), Betacoronavirus (betaCoV), Deltacoronavirus (deltaCoV), and Gammacoronavirus (gammaCoV). SARS-CoV-2 belongs to the betaCoVs genus with genomic characterization showing bats and rodents as its probable gene sources. Viruses of the Coronaviridae family can cause respiratory, enteric, hepatic, and neurological diseases in different animal species, including camels, cattle, cats, and bats. To date, seven CoVs capable of infecting humans (HCoVs) have been identified (Cascella, Rajnik, Cuomo, Dulebohn & Di Napoli, 2020). Understanding the aetiology of the virus moves us closer to the development of useful therapeutic agents and vaccines. From this perspective, the term 'Wuhan virus' is arguably, not particularly helpful...

The controversies surrounding the naming of the virus and the role of the WHO are examples of what David Rancinun (2020) calls the "contiguous nature of science and politics." We see scientists on media briefing podiums with political leaders in a daily spectacle that irrefutably precludes science being represented as apolitical (if it ever could have been). While philosopher Slavoj Žižek (2020) suggests "the

virus hides no deeper meaning,” the global response to COVID-19 has emerged as an assemblage — a technoscientific, geopolitical, sociocultural and economic fluidity — that contrarily veers from gracious acknowledgements for those on the ‘front line’ (‘clap for carers’), to deep ambivalence (sometimes disregard, as in the case of the hydroxychloroquine dispute) for expert health advice, even as that same advice is simultaneously legitimated and disparaged from political podiums. The President of the Federation of American Scientists, Ali Nouri, on April 15th, 2020, denounced the Trump administration’s response as “grossly inadequate,” admonishing it for “not letting the science drive the conversation ... We’re letting the Dow Jones Industrial Average drive the conversation and that has been a problem” A month later in the US, despite the virus’ human costs (topping 100,000 deaths as I write), little seems to have changed. On May 12th 2020, at the Health, Education, Labor and Pensions Senate Committee hearing on reopening the US economy, Republican Rand Paul challenged Trump’s most senior pandemic advisor and Director of the US National Institute of Allergy and Infectious Diseases Dr. Anthony Fauci, when the latter urged caution: “Dr. Fauci, I don’t think you’re the end-all. ... We can listen to your advice but there are people on the other side saying there’s not going to be a surge [in cases] and that we can safely open the economy” (Feuer & Wilkie, 2020).

So why are the expert “scientists and other respected professionals” (to borrow Pelosi’s phrase) from the WHO and national institutions like the CDC (which has been heavily criticised by the Trump Administration) being simultaneously valorised and vilified? Clearly, understanding the “contiguous nature of science and politics” is now more pressing than ever, as we grapple with arresting the pandemic and charting new ways forward. It is a fundamental question for science education to consider, given its role in the production of future science and medical professionals, who will be called to navigate these highly charged and contested political spaces. Moreover, the virus has thrown the public’s understanding of science into renewed focus, underscoring the importance of the technical knowledge required to interpret graphs, growth rates and spread, understand basic virology, vaccine development, antibodies, hygiene and so on. Long an agenda within science education, the public understanding of science is vital to enable citizens to distinguish disinformation and ‘fake news’ from important public health messages, promoting public acceptance of social distancing, contact tracing and other practices fast becoming the new normal.

Developing a perspective on some aspects of the current geopolitical landscape helps render the entangled scientific and political currents of the COVID-19 pandemic a little more intelligible. More specifically, the coterminous trends of post-liberalism’s shifting power relations and the rise of right wing populism (RWP) offer some explanation, I believe, as to why scientific expertise and technocratic knowledge has been diminished in a cacophony of political posturing and blaming. Developing this argument requires a more detailed political discussion — in this case, genealogy — than is usual in science education scholarship, but finds support in the 2021 American Educational Research Association (AERA) Annual Meeting theme requiring political literacy to better understand the interplay between our scholarship and societies (AERA, 2020). Hence, I begin with a review of the Western political positions of liberalism, neoliberalism and post-liberalism, focusing on the decline in the liberal global economic order in place since the 1950s, thereby proposing the contemporary post-liberalism trend as a consequence of its liberal and neoliberal antecedents. Following on, I consider the rise of RWP as an instance of post-liberalism apparent not only in the recent attacks on scientific elites/experts/institutions, but also in declining multilateralism that erodes organisations like the WHO. I finish with some comments on the effects of these trends for science education though its early days in these fluid spaces.

What's in a Name: Liberalism, Neoliberalism, and Post-liberalism

Liberalism and Neoliberalism

Liberalism can be understood as the ideology, political theory, practice and discourse of modernity. With its roots in the Western Enlightenment, and in its many iterations across various temporal, geographic and sociocultural settings, the liberal project, Gray (1995) argues, sought universal principles by which plural and divergent conceptions of the world could coexist. Generally, three facets of liberalism have been important in the West, post World War 2. Firstly, 'embedded liberalism,' agreed at the 1944 Bretton Woods conference shaping future international governance/economics, meant Keynesian economics and regulated market capitalism within social democracies (Ruggie, 2003). In many settings, this rationale underpinned the creation of the welfare state. Secondly, liberalism informed the establishment of multilateral institutions and bureaucracies like the United Nations, of which the WHO is a part, and spaces for international debate and accord (Helleiner, 2019). Finally, the moral purpose always encoded and prominent within liberalism was increasingly expressed in progressive agendas like individual and human rights, gender and racial equality, and religious tolerance (Duncombe & Dunne, 2018). Science (as Western modern science), engineering and other specialist rational technocratic knowledges and practices flourished under this liberal world order. Since Bretton Woods, liberalism has arguably been US dominated — economically, politically, militarily and diplomatically — and, while clearly a hegemonic and colonising project, it has enabled some functional multilateral consensus and emancipation (Barrinha & Renard, 2020). Gray (1995), however, reminds us that what was fit for purpose in modernity was always going to flounder in the postmodern.

Social welfare liberalism began to fray during the 1970s fiscal crises, when Keynesian economics could not halt stagflation. At the same time, increased technological innovation, digitisation, extensive physical infrastructure growth, greater global mobility, identity politics and the decolonisation of the Global South, was propelling the world economy into its next stage — globalisation. Neoliberalism prevailed as the new mode of capitalist global relations, privileging free markets above regulated social capitalism. The welfare state and domestic economic sovereignty was out and the financialisation of the global economy was in. The state's new mission was to govern principally for the market, drafting laws, instituting (fiscal and other) regulatory apparatuses, and recalibrating public administrative entities to align with the enterprise state. Competition was the central logic upon which neoliberal marketisation rested: competition between enterprises, between workers, for goods and services, and for scarce natural resources. Along with the highly visible 'winners,' competition also produced 'losers,' be they nations, groups or individuals, allowing Davis (2014) to observe that competition and inequality are the very essence of neoliberalism.

By the end of the Cold War in the early 1990s and onwards, neoliberal globalisation was so dominant that it prompted Francis Fukuyama (1992) to proclaim the 'end of history.' Nations around the world including Russia and China embraced market economies as the only way of doing business, with China, in particular, a spectacular 'winner.' Over these decades, institutions and practices of liberal multilateralism also reflected the changes from social welfarism to neoliberalism with many multilateral organisations being reformed along corporatised market lines (Helleiner, 2019).

Twenty-five years on, however, global markets have reconfigured the world's economic and sociopolitical landscape to such an extent that even powerful states like the US could not protect their

citizens from the resultant inequality. Economist Thomas Philippon (2018) argues that globalisation and unfettered neoliberalism has, within the US, progressively concentrated corporate power. Rising corporate profits have been directed upwards as middle and working class employment have spiralled downward, becoming casualised, insecure and low wage. For Martin Wolfe (2019), this heralds a move towards oligopoly, where the market is dominated by a small group of large players (Alphabet, Amazon, Apple, etc., incidentally all turbocharged by COVID-19), and towards a politics of plutocracy, where power is invested with a small number of wealthy people. Within this trajectory, neoliberalism alters as larger and larger monopolies disavow the competition that is collapsing the very heart of the project.

Intensifying deregulation, privatisation and mounting inequality has provided fertile ground for the growth of populism, particularly right-wing populism (RWP). Most recently, populist groups helped propel to power Jair Bolsonaro in Brazil, Viktor Orbán in Hungary, and Trump in the US, amongst others, and advanced the agenda of right-wing or ultranationalist political parties like the Alternative for Germany (AfD). Political philosopher Nancy Fraser (2017) discusses Trump's ascendancy around the twin tropes of 'distribution' and 'recognition,' where 'distribution' refers to the economic structure of society or how goods, especially income, are allocated, and 'recognition' explores how society apportions respect and esteem (for experts and others) and the moral marks of belonging. Writing for the US context, but with applications more broadly, Fraser (2017), argues that political economies of any shade — left, right or center — have all embraced neoliberal distribution which, as we have seen, ensures the net transfer of wealth from the majority to an increasingly concentrated minority. It is thus, in recognition, where the politics play out. In the postmodern era of identity, 'progressive' recognition retains liberalism's moral purpose promoting egalitarianism and emancipation amongst diverse groups. Hence, progressive neoliberalism (usually associated with former US President Barak Obama or the Third Way politics of Tony Blair in the UK, as well as with the ideological project of the European Union), has successfully advanced some minorities/identity groups already in possession of the requisite social capital. Progressive anti-neoliberal agendas on the other hand, like those of Bernie Sanders and Jeremy Corbyn promoted a more socialist vision, that appealed largely to educated, middle class and youthful constituencies who were highly vocal but ultimately marginalised.

By contrast, 'regressive' recognition or RWP drawn from traditional social conservatism promotes "ethnonational, anti-immigrant, and pro-Christian, if not overtly racist, patriarchal, and homophobic" discourses and practices (Fraser, 2017 p. 54). The imagery is one of an at-risk, idealised and homogenised homeland. Regressive recognition or RWP rejects elites, particularly middle class technocrats/experts, multilateralism and pluralism (in other words, it rejects the liberal project), as it simultaneously venerates charismatic anti-establishment leaders offering simple solutions to complex issues. Neoliberalism and concentrated corporatisation remain firmly entrenched as the blame for inequities are directed elsewhere. Trump's 2016 presidential campaign, run on tropes of protectionism, nationalism and xenophobia, successfully melded these exclusionary regressive positionings with the mass of neoliberal 'losers' (particularly working class white males) into what Fraser (2017 p. 56) identifies as "a new proto-hegemonic bloc."

As the COVID-19 pandemic unfolds, it has been leveraged by reactionary populism decrying economic lockdown, as well as the immigrants and elites who have bought in the pestilence — literally and figuratively — enabling it to take hold amongst the undesirable, and racialised other. Rallies, sometimes armed, in Europe, Brazil and the US sloganise: in Germany, facemasks are described as 'Merkel's muzzle,' in the UK 'corona is the cure — humans are the disease', while placards in the US

entreat 'liberty or death' and carry the infamous phrase that crowned concentration camp gates, 'Arbeit Macht Frei' ('work sets you free.')

With hindsight, the fragmenting social fabric, and global financialisation untethered from any moorings, was always going to challenge the 75 year plus framework of postwar liberalism. We have seemingly arrived at a point of post-liberalism where Trump's (and others') protectionism, nationalism and regressive or reactionary populism has denied liberal democratic multilateralism and moral purpose. It is to this post-liberal reality that I now turn.

Post-liberalism

Barrinha and Renard (2020) suggest that, while scholars differ in nuance, there is general agreement "that the hegemony of the liberal world order (in place since Bretton Woods) is over". Given previous US dominance in the liberal world order, post-liberal essentially means 'post-Western' or 'post American,' and signals a "'crisis of authority' in American leadership (p. 4)," particularly on the global economic stage. A second feature of post-liberalism are the calls to reform (or disregard) rules-based multilateral institutions like the UN (including the WHO), alongside the emergence of new non-Western international institutions like the Asian Infrastructure Investment Bank (AIIB). Thirdly, post-liberalism focus on the loss of liberal norms and values as a consequence of the rise of illiberal practices and discourses like RWP. These trends are mutually reinforcing, argues Hendrick-Wong (2019), as populists see neoliberal globalisation and Western economic decline as failures of the liberal world order. Barrinha and Renard (2020) go on to suggest that the 'post' prefix highlights the uncertainty surrounding liberalism's current direction, echoing Fraser's (2017) use of Antonio Gramsci's dictum (1930/1971, p. 276): "The crisis consists precisely in the fact that the old is dying and the new cannot be born; in this interregnum a great variety of morbid symptoms appear." For Gramsci, times of interregnum are times of uncertainty and risk, as the new "is still at the designing stage, has not yet been fully assembled, or is not strong enough to be put in its place" (Bauman, 2012, p. 50). These sentiments seem particularly apt for the uncertainties that the COVID-19 crisis presents.

What we do know about post-liberal times, however, is that the world's power dynamics are shifting, with the US retreat into protectionism and nationalism, the rise of China as a non-liberal, authoritarian and competing state, along with, for Duncombe and Dunne (2018), "potent identity-based mobilisations, "illiberal democracies", as well as the rise of transnational Islamic insurgency" (p. 27). China's triad of policies constituted by the 'belt and road initiative' (massive investment to improve physical infrastructure in 70 countries in Europe, Asia and Africa), the 'made in China 2025' strategy (aimed at developing China's technological supremacy), and 'military-civil partnership' (that sees every citizen working for China's national goals), is a viable and present threat to US hegemony. Moreover, China's non-liberal authoritarianism demands acknowledgement of the relativity of values and norms that sits beside Western RWP challenges to progressive liberalism and its notions of recognition and emancipation. In other words, China's success at global market relations have not required China to embrace liberalism's other facets. Political scientist Joseph Nye Jr (2016, p. 14) argues that in the post-liberal world marked by the rise of the non-Western states and variable values, "governments will continue to possess power and resources, but the stage on which they play will become ever more crowded, and they will have less ability to direct the action."

We also know that post-liberalism coincides with some global fragmentation and reduced material and people flows consequent upon the 2008 global financial crisis (GFC) — known as ‘deglobalisation’ (Ortega, 2020). The GFC initiated a shift from fiscally cheap, offshore manufacturing and “just-in-time” global supply chains to more regionalised or localised ones. Several factors coalesced to produce these changes known as ‘reshoring’ in the US, and developed there during the Obama Administration. Firstly, the rapid translation of science and technology innovations into the manufacturing process of additive manufacturing or 3D printing, high-performance computing, automation and robotics, and adaptive manufacturing that flexibly produces demand-driven products, has enabled small volumes of locally produced parts to become economically competitive. Secondly, the rising production costs of China’s manufacturing as a result of wage rises and China’s move to a service economy, also makes local products competitive. Thirdly, growing environmental and climate costs have made consumers increasingly aware of the long supply chain impacts and energy intensive transport costs. Finally, the US-China trade war, BREXIT and other global disruptions have increased uncertainty in cross-border supply chains through both tariffs and investment restrictions (Ortega, 2020). Moreover, Linda Yeuh (2020) argues that an expanded definition of national security (for example, key telecommunications, energy, medical supplies, defence systems) has included securing supply chains, with greater emphasis on national resilience (not readily apparent though, for pandemic medical supplies...). Digital globalisation in the form of financial services, online shopping, entertainment, and so on has increased as trade goods have decreased, marking a change, rather than a decline, to globalisation. The COVID-19 pandemic has further accelerated these preexisting trends to renewed nationalism, exacerbating the post-liberal challenges of managing environmental and technological changes, securitisation, and geo-economic concerns, in concert with preserving the open trade and investment that a sophisticated global economy requires.

An important aspect of new post-liberal world is the sustained attack by RWP on elites and experts. There is of course, great differences in meaning attached to these terms. Elites may be elite owing to wealth, celebratory, hereditary entitlement or other factors, without laying claim to any technical expertise. Experts though, are usually elite by virtue of special authority conferred by education, technical knowledge, professional self-regulation and restrictive licensing common to doctors, lawyers, scientists and others. At a time when technocratic elites from hospitals, research laboratories, universities, think-tanks, the WHO, the CDC, political agencies and NGOs are arguably vital to appropriate pandemic responses, their diminishing and conflicted place in the popular and political discourse demands greater explanation.

RWP and Expert/Elite Knowledge

Populism as an ideology conceives of post-liberal society as separated into two antagonistic groups, ‘the people’ and ‘the other’ where the latter are immigrants, non-heteronormative groups, non-Christians, non-Whites as well as experts and elites (Gökmen, 2017). In his 2016 election pitch, Trump championed ‘the people’ at the same time he vilified the technocratic experts, promising to ‘drain Washington’s swamp’ (a legitimating reach back to Republican President Ronald Reagan’s slogan). Similarly, UK politician Michael Gove argued during 2016 BREXIT campaign that, “I think the people in this country have had enough of experts with organisations from acronyms saying that they know what is best and getting it consistently wrong. ... I just want people to trust themselves rather than the elites.” Given the privileged backgrounds of both Gove and Trump, Davis and Williams (2017, p. 4) wryly

observe: “this blue-collar revolt against elites/experts is being managed and directed by the very same elites.”

Neoliberalism, as we have seen, paved the way for RWP attacks on technocratic knowledge and their actors (also Müller, 2020). Will Davis (2017 p. 236) notes that early neoliberals like Friedrich von Hayek believed “intellectuals possess too much power in circulating ideas which, when coupled to the state ... believe they know what is in the interests of all, and then set about establishing plans through which to pursue this.” Hayek, of course, believed the randomness (chaos) of the free markets were better instruments of distribution than the rational technocratic planning championed by ‘intellectuals’ or technocratic experts (such as scientists, engineers, health professionals, statisticians) that existed under the embedded liberalism and welfarism of the mid last century. With the development of pseudo-markets in universities, hospitals and research settings under neoliberal reforms of the 1990s, much ‘blue sky’ research was abandoned for applied processes and products that came to be equated with increasing national gross domestic product in the hyper-competitive global economy (see for example, Stephan, 2012). It also saw the erosion of technocratic self-regulation mechanisms for sanctioning knowledge acquisition, legislating membership and other conventions that ran counter to free market orthodoxy.

Not all elite/expert knowledge however, has been devalued. Financial entrepreneurs are emerging as the new elites of neoliberal globalisation (Davis & Williams, 2017). Innovative forms of digital value extraction and surveillance (see Zuboff, 2019) have forged a new alliance of bankers, traders, hedge funders, data brokers, entrepreneurs, capitalists and symbolic workers able to rapidly make or break fortunes. Previously of lesser status, the alpha elite financiers are perversely celebrated by RWP as inspirational role models. Financial elites leverage technocratic knowledge when required, on a pay per service arrangement, with the downwardly mobile specialist now seen as “‘diplomatic intermediaries’ whose job it is to interpret and communicate the meanings of finance (and associated machinery) for the benefit of public audiences” (Davis, 2017, p. 243). In other words, scientists, engineers, medical professionals and other rational technocrats no longer command esteem and respect afforded them under liberalism, but become service providers akin to any other in a market economy. Not surprisingly, in the post truth/fake news era, public confidence and trust in experts has declined, allowing legal scholar Albert C. Lin (2019, p. 305) to observe, in science domains, for example, that the “view of scientists is generally soft rather than strong”, and “trust in scientists with respect to certain issues is comparatively low.”

Following the Science

Various national governments have claimed that their COVID-19 response has been based on high quality expert advice — ‘the best scientific advice possible.’ Indeed, the UK government has said on many occasions that it is ‘following the science’ in tackling COVID-19 (King-Hill & Powell, 2020). The difficulty, though, for populist leaders is that having bound themselves to the imaginary of ‘the people’ whom they alone are qualified to represent, they must necessarily be anti-elite/expert. This means at best, an ambivalence towards the expert knowledge, which helps explain why the track record of many populist politicians (Trump, Johnston, Bolsanaro) on COVID-19 has been criticised as unclear, contradictory or lukewarm.

Lin (2019, p. 252) draws attention to the ‘regulatory’ science regime where science intersects with politics/law in policy production of the type necessary for battling COVID-19. Regulatory science goes further than just knowledge production; it includes the knowledge synthesis and prediction required for

“informed opinions about the plausible consequences of our actions (or inactions), ... monitoring the effects of our choices.” Lin (2019, p. 249) discusses Trump’s systematic undermining of regulatory science over the past few years, arguing that:

To stifle scientific activity, the Administration has proposed deep cuts to research funding on specific topics and ordered scientists not to present unfavorable results. To weaken the role of expertise, the Administration has skewed membership on some scientific advisory committees toward industry and dissolved or reduced the role of other committees. And to undermine the use of science in policymaking, the Administration has questioned methodologies and truths that are widely accepted by the scientific community.

Moreover, Trump’s funding cuts and the appointment of non-scientists to head scientific agencies exemplifies a disdain for science and its expertise, characteristic of RWP and the post-liberal.

Of course, there is no such thing as ‘the’ science. There are many scientific views, some possibly contradictory: in short, experts disagree. Uncertainty abounds in traditional experimental science, in which the answer is narrowed with evidence over time. With COVID-19, the uncertainty is extreme and the evidence is, at this time, very provisional. At the natural intersection of scientific and political uncertainties, the selection and promotion of evidence can’t help but be ideologically driven. Moreover, politicians have always favoured the kind of science that aligns with their existing preferences, Bacevic (2020) observes, even as they have declared themselves as ‘following the science.’ This strategy appeals to the simplistic view of science amongst the populace as an objective process that “produces clean yes or no answers” (Lin, 2019, p. 254). The challenging realities of vaccine production, questions of antibody durability, the efficacy of therapeutic agents, transmission modelling and so on can be spun, if necessary, as the failure of experts and not the failure of politicians. Such is the concern amongst scientist themselves that Sir David King, former chief scientific adviser to the UK government, has convened a panel of experts as an alternative to the Scientific Advisory Group for Emergencies (SAGE) which officially advises the UK government on COVID-19. SAGE has been criticised for its secretive political membership and lack of transparent decision-making, which Sir David believes has eroded public trust in science (Devlin, 2020).

Similarly, Trump has been the master of scientific disinformation with his stream of tweets and press conference pronouncements, sowing confusion amongst experts and the public alike. Appropriating Franz Fanon’s (1963) term from his seminal text *The Wretched of the Earth*, Trump is a ‘bewilderer,’ a master mediator, obscuring the reality between power (in this case, the oligarchs) and the people. From claims that the virus originated in a Wuhan laboratory (contradicting his own intelligence community), to hyping hydroxychloroquine and the infamous ‘Lysol moment,’ (“I see the disinfectant, where it knocks it out in one minute, and is there a way you can do something like that by injection inside, or almost a cleaning”), or UV light therapy, (“supposing you brought the light inside the body, which you can do either through the skin or in some other way”), Trump has relentlessly challenged the technocrats and experts. He views the over 1.9 million confirmed US cases as a “badge of honor” and a “great tribute” to the testing regime. In a play on words, Charles Sykes (2020) describes the ‘Faucian Bargain’ scientists at the White House have had to strike in order to exert some influence over the pandemic response (Faucian referring to Anthony Fauci, instead of Faustian). Whatever Trump’s motivations, his exaggerations and false claims are rhetorical attacks on science, consistent with the post-liberal status decline of technocrat knowledge. His comments remind his RWP support base to be sceptical of the experts, as he alone knows what is best — after all, he is a self-proclaimed ‘very stable genius.’ Scientific authority and influence in society has been weakened when it is most needed, argues Gabbett (2020) with Keir Giles (2020), proclaiming the pandemic to be “a golden moment for disinformation.” That such behaviour is tolerated is a mark of the post-liberal world, and speaks, Bruce Shapiro (2020) believes, to a larger agenda of Trump’s on dismantling

accountability protocols in the battle over limits to Presidential power. Ultimately, though, it is reassuring to know that many countries have followed experts' recommendations on testing and tracking protocols, and isolation and social distancing measures within their respective economic, political and social constraints.

Scapegoating the WHO

Trump's attacks on the WHO also make some sense, given RWP's distrust of multilateral organisations and the retreat to nationalism characteristic of post-liberalism. Prior to the pandemic, the US was already reviewing WHO's funding, proposing a \$65 million cut for the 2021 fiscal year, a decrease of more than 50% on the 2020 figure (Klein & Hansler, 2020). The WHO's website financial data also indicates that the US was already in arrears of over \$81 million for some the 2018/2019 payments (WHO, n.d). Established in 1948 with an ambitious charter but a very small budget, public health researcher Sara Davies (2020) argues that, from its inception, the WHO was torn between members who believed its mandate should promote universal health goals and those who saw a more limited remit of technical advice. These views were variously privileged by different Directors General over the decades. Former Norwegian Prime Minister, medical doctor and human rights advocate Gro Harlem Brundtland, Director General from 1998 to 2003, for example, sought to reform and expand the WHO's mandate. Controversially, during the 2003 SARS outbreak, Brundtland unilaterally issued the WHO's first borders and travel advisory against travel to the Chinese epicentre. Trump argues in his letter to the WHO's current Director-General Tedros Adhanom Ghebreyesus, on May 18th, 2020, that had Brundtland's action been replicated for COVID-19 "many lives could have been saved." Trump's letter not only rebukes Ghebreyesus, but also chronicles the WHO's "missteps" and continues to attack China. The letter demanded that the WHO "demonstrate independence from China" and "commit to major substantive improvements" or face permanent funding withdrawal. The following day, *The Lancet* described some of the letter's information as "factually incorrect" (The Lancet, 2020).

On May 29th, 2020, Trump announced the termination of the US's relationship with the WHO. It is not so straightforward, though, Madhukar Pai (2020) argues, with legal requirements of a year's notice and paid up financial obligations that put the withdrawal timing beyond the next election. Rather, the move is seen as an attempt to distract from the US's high COVID-19 toll, the protests consequent to the death of George Floyd, and simultaneously, an expression of Trump's distaste for multilateralism that has seen him also quit the UN Human Rights Council, the UN cultural agency UNESCO, a global accord to tackle climate change, and the Iran nuclear deal.

Davies (2020) argues that, despite Trump's rhetoric, the WHO has largely followed its infectious disease notification protocols for COVID-19, established in 2005 post SARS which, in part, aimed to block precipitous moves like Brundtland's. Infectious outbreaks and public health emergencies are now the remit of a committee seeking to balance a myriad of effects resulting from border closures with transparency from member states that is not always available. The highest level of alert in the WHO's arsenal is a Public Health Emergency of International Concern (PHEIC) warning, which it declared January 30th, 2020. PHEIC's are rare, but public recognition of their severity is "extremely low," even by the WHO's member states. Helen Thompson (2020) believes that, outside Asia, the PHEIC alert failed to be recognised and operationalised in a timely manner, as there was "no prior politics of pandemics." In other words, nations needed first, to be convinced of the problem (readily apparent after the outbreak in

Italy), and second, political responses conceptualised in an acute situation with uncertain data and information flows. Clearly, the WHO is vulnerable to criticism, and challenges will remain given that member states do not always behave by the rules.

In what Patrick Wintour (2020) argues was a symbolic international endorsement of the WHO, EU and non-EU leaders together with important agencies like the Coalition for Epidemic Preparedness Innovations (CEPI), the Global Fund, and the Bill & Melinda Gates Foundation (BMGF) met on April 24th, 2020, promising a renewed global cooperation around five pledges. Précised from the WHO website, they pledged to:

- Provide access to new treatments, technologies and vaccines across the world
- Commit to international partnership on research and coordinate efforts to tackle the pandemic
- Reach collective decisions on responding to the pandemic, recognising that the virus's spread in one country can affect all countries.
- Learn from experience and adapt the global response.
- Be accountable, to the most vulnerable communities and the whole world.

On May 4th, 2020, the group committed 7.4 billion euros for vaccine, diagnostics and treatment development. The US did not, and will not, participate in further scheduled meetings. A resolution at the WHO's 73rd World Health Assembly on May 19th, 2020, passed by more than 130 countries called for intensification of virus control efforts, and for equitable access to all essential health technologies and products. Stepping into some of the void vacated by the US, China pledged \$2 billion over two years to support Covid-19 response efforts, particularly in developing countries. For Chatham House's Robin Niblett (2020), "the American approach to the coronavirus continues to play into the narrative of the United States isolating itself, and it also shaves off another layer of the U.S. long-term legitimacy." Certainly, these meeting of commitments indicate that multilateralism still has some currency, as does the moral purpose of the liberal world order seeking the protection of the vulnerable (Duncombe & Dunn, 2018). Nevertheless, repeated attempts to scapegoat the WHO, when coupled to member states nationalistic disregard of protocols/reforms to which they have agreed at previous World Health Assemblies, also speaks to the rise of nationalism and the decline in multilateralism that is a hallmark of the post-liberal.

While comparison amongst countries may not always be helpful, the differences between South Korea and the US who both confirmed their first COVID-19 cases on January 20th, 2020, is worth comment. South Korean officials moved quickly to coordinate with the private sector, producing a test based on the WHO's recommended gene targets, and began testing more than 20,000 people a day. They reactivated legal and physical infrastructure in place from their prior exposure to another coronavirus first reported in 2012 — the Middle East Respiratory Syndrome (MERS). In the US, the CDC developed its own test, focused on three gene targets distinct from those of the WHO. By February 29th, 2020, CDC data indicated that only 472 patients had been tested nationwide, with 22 cases confirmed from a reportedly flawed test (CDC, n.d.), while in South Korea, nearly 990,000 tests were completed with around 2000 confirmed diagnoses (Statista, n.d.). The outcome in both countries is now a matter of record, notwithstanding a small second wave of infections in South Korea.

The Old is Dying and the New is Yet to be Born

Writing in 1996, John Gray envisioned the extraordinarily difficult task before us in developing a pluralist political theory, in which the liberal problem of finding a way amongst rival world views is solved

in post-liberal terms (Gray, 1996). Gramsci's (1930) reflection on the dying old order without a new one to replace it seems apt. Ostensibly responding to Gray, and writing just prior to the COVID-19 outbreak, Hendrik-Wong (2019) posited the multipolar postliberal world as the balkanisation of the global economy into separate but overlapping, politically flexible networks formed around the 'hub economies' of the US (oligopolistic corporate political-economic model), China (authoritarian state-led capitalism), and Europe (a legalistic-bureaucratic model). Other nations would align within these self-organising and continually evolving networks in trade, technology, military and other terms, but may also straddle networks as required. Financial/digital globalisation will continue Hendrik-Wong (2019) argues, albeit it more regionalised supply lines, but without multilateralism, we will be "less effective in coordinating actions in meeting challenges like global warming and pandemics." Perhaps he was prescient. Writing from the grip of the pandemic, Adam Tooze (2020) believes we are already well along this multipolar path, but as each of these 'hubs/blocs' has entrenched structural and fiscal weaknesses, our post-liberal future faces severe difficulties that COVID-19 has only further revealed and exacerbated.

Certainly, 'lockdownonomics' (to borrow Runciman's (2020) term) and the unprecedented government financial interventions to stabilise economies has pundits prophesising anything from new democratic forms acknowledging the social side of the ledger, to austerity neoliberalism and authoritarianism to help pay the bill. Hungary's populist leader Viktor Orbán move to rule 'by decree' introduced under the pandemic emergency, is certainly an example of the latter, while Žižek (2020) celebrates the former, suggesting there is something profoundly radical in the ways states have embraced an anti-economistic logic through lock down. As we move from the pandemic's acute stage into a tentative future of easing restrictions, another Gramscian-type interregnum, we are entering what crisis and risk analysis scholars Argen Boin and Martin Lodge call a 'Twilight Zone.' The Twilight Zone, "is marked by deep uncertainty about both the chance that a threat may materialize and the escalatory trajectory it may follow." In terms of the ongoing nature of COVID-19, "it requires a capacity not just to 'relax' or restore 'full lockdown', but also to maintain and enforce partial 'lock-down' in the face of inevitable calls for more (and less) relaxation" (Boin & Lodge, 2020). Having made some sense of the crisis, we now have to make sense of the "great easing" with the need to restore economic life in flux with mitigating a potentially lethal second wave.

COVID-19 is the third of three world shocks (or possibly, resets) experienced in a century that is barely 20 years old: 9/11 and the war on terror from 2001, the GFC of 2008 and now the pandemic. We also face the creeping existential crises of climate change and ecological devastation. Clearly, living in this uncertain post-liberal world in the time of coronavirus requires of us to develop new kinds of resilience of which we are just becoming aware.

What about Science Education?

Having characterised at length the *mise-en-scène* in which the pandemic is situated, in the brief space remaining, I sketch three implications for science education. Each is suffused with my personal socio-political vision of distribution and recognition privileging social and ecological justice (see Carter, 2010, 2014, 2017, in press). They are necessarily speculative given the pandemic's fluid, rapid and multiversal nature, requiring sustained consideration over time, for as Nancy Fraser believes, "you can't fall back on the same old bromides that are so patently useless" (Chang, 2020).

Firstly, and most obviously, COVID-19 signals curriculum possibilities including relevant knowledge and skills-based topics like, for example, basic virology and immunology, epidemiology, data modelling and interpretation, and testing and tracing. The pandemic becomes another, somewhat pressing, socially acute question (SAQ) or socio-scientific issue (SSI) with which to engage. For example, how zoonotic viruses cross species barriers with accelerated human impacts on natural environments, and their downstream effects. Another SAQ/SSI could investigate local production of medical supplies, as an example of the rapid scientific translation technologies that are so altering our world. Yet another could focus on the role of the WHO and other national and international scientific bodies in fostering better global health outcomes. These SAQ/SSIs all require multiple areas of scientific understanding, readily apparent in school science curricula, interplayed with relevant socio-political perspectives.

Further, as most schools were closed during lockdown, investigating science curriculum delivery on-line and by other distance mechanisms develops a new research area. Most challenging here is understanding and mitigating the inequities endemic in our schools, to improve possibilities for vulnerable students likely to miss out from prolonged school absences.

A second and related implication arises from RWP's increasing disdain for science, exemplified by, as we have already seen, authority figures legitimating scientific disinformation, as well as sustained public attacks on, and declining esteem for, scientists and institutions like the WHO and CDC. In response, the sub-specialisations within school science of 'the public understanding of science' and 'the nature of science,' require a renewed and refocussed approach. Clearly essential, is reinforcing an appreciation of the provisional nature of science: how uncertainty may be narrowed with evidence over time, and how scientists may disagree, or have contradictory views, even when discussing similar data. What is usually excluded from these discussion's though, is a consideration of the sociopolitical construction of science. While scholars like Larry Bencze (2008) and Derek Hodson (2010) have long argued for the political contextualisation of science education, such an approach is now critical given science education's role in the production of future professionals who will be called to navigate these highly charged and contested political spaces. It is no longer tenable to present science as decontextualised 'objective' knowledge for its own sake, or in a linear progression to further knowledge. Understanding some of science's political grounding would help to address Lin's (2019, p. 254) concern regarding the public's simplistic view of science as an objective process that "produces clean yes or no answers." In addition, a sociopolitical perspective mitigates against the risk of science education being hijacked by regressive populism, in ways that are only just becoming apparent as RWP regimes (like Hungary) begin reforming education (see 12 Rules for What, 2020, also Thompson, 2016). These reforms typically leverage structural neoliberalism, and compliance to narrow vocational and utilitarian curricula that reinforces nationalism and ethnocentrism.

Finally, but perhaps most importantly — moving beyond science education's traditional knowledge and skills production remit — is the facilitation of resilience development necessary to brave social and environmental hazards that include COVID-19. A complex, dynamic and multidimensional phenomena, resilience usually refers to a range of social and emotional factors shaped by individual and situational characteristics that enable positive adaptations in challenging settings. While educators are increasingly aware of its importance, science education, with minor exceptions (see for example, Marshall, 2018; Quigley, 2017), has been slow to engage with resilience. Not surprisingly, the higher visibility of resilience within environmental education literature speak to young people's well known concerns about their ecological future. Resilience is fostered when actors are confident in their understanding of hazards and

can produce risk mitigating action plans. Within science education, for example, the knowledge behind an extreme weather event like a tornado or cyclone would be developed alongside response plans for individual and local community action. Activist science education projects to address SAQs like Larry Bencze's (2020) *STEPWISE (Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments)* that utilises student scientific and technological understanding to inform decisions about student actions, provide great promise here.

Bewilderment in the Twilight Zone – Some Concluding Comments

As we move further into the uncertain post-liberal future, on one reading, my faith in some aspects of the 20th Century liberal tropes of social welfare, state intervention, multilateralism, and equity and emancipation makes me not only a 'small l' liberal but a 'small c' conservative, who seeks to conserve things of worth. On the other hand, I am acutely aware of the exploitative and colonising economics of power, as well as the potential for cultural and identity erasure of this type of liberal universalism (maybe I'm a socialist?). Having lived the past few months of the COVID-19 pandemic, and in writing this article, I am left, all told, somewhat bewildered in the Twilight Zone. How will we navigate this risky future? What are the possibilities for education more generally, and science education in particular, in a post-liberal, pandemic world? Will we attempt 'business as usual', or as I believe, alongside AERA's 2021 conference call, should we start to take seriously the role (science) education plays as global *res publica*? Clearly, the emerging sociopolitical arena which ultimately constitutes science and science education needs careful and thoughtful consideration. There will be much with which to wrestle in the coming years.

And finally, in ending, I think I will give the last word to the former Australian Prime Minister Malcom Turnbull (2020) when he suggested that "this is biology confounding politics ... this virus defies our very humanity."

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Post-pandemic Science & Technology Education

An Opportune and Necessary Ideological Battle

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Responses

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Abstract. Much of the world is experiencing a crisis in which many ‘instructional packets’ (SARS-CoV-2 viruses) have commandeered ‘machinery’ of living beings to propagate themselves — regardless of surrounding harms their self-interested purposes may cause. Although they have, indeed, caused massive global disruption, crises linked to hegemonic actors are not uncommon. Capitalists, like viruses, conscript various living and nonliving entities to serve them and, in their persistent — and, generally, highly-successful — pursuit of profit, are said to be responsible for numerous social injustices and much environmental devastation, such as climate disruption and nuclear war (Ripple et al., 2020). Accordingly, like viral pandemics, many suggest that capitalism is a ‘pandemic’ and also must be eliminated — and, some would suggest, replaced with eco-socialist worlds. Capitalism seems, however, to be extremely resilient, often able to survive different crises and, sometimes, capable of emerging even stronger. In this vein, Naomi Klein (2007) suggests that capitalists and others have routinely exploited natural and anthropogenic disasters — using societal destabilization to further implement pro-capitalist policies, often at expense of well-being of many people (e.g., gig workers), societies (e.g., under surveillance) and environments (e.g., climate change). The CoViD-19 pandemic, however, may be a special kind of crisis — perhaps opening doors to more non-capitalist futures. Although enabling, for instance, more for-profit surveillance, it also may have disaggregated capitalist networks to the point of severe weakening and, in doing so, enlightened many people about pre-crisis neoliberal and populist infrastructures that may have contributed to this and other crises. Such *conscientization* may, in turn, have emboldened many to work for better futures. Given roles of science and technology (S&T) in capitalist empowerment, a natural place for such transformation may be science and technology education. In this paper, a framework for S&T education showing promise in this regard is described and defended. Nevertheless, those wishing societal transformation towards more eco-socialist futures need to engage multiple and diverse living, non-living and symbolic entities in ways that may generate networks supportive of such transformations.

Keywords: Capitalocene • crises • science & technology education • technoscience funding
• ideological struggles

Introduction

As I write this article in late June 2020, over 500,000 people have died worldwide from complications related to infection from the 2019 novel coronavirus pandemic¹. It also has caused massive global disruption — with billions of people practising self-isolation, untold numbers of business closures and cut-backs (with people forced out of work) and millions of people risking their own health by continuing to work in different essential services (e.g., health care and food provisions). There is currently much uncertainty about this crisis, when it might end, and, when most people may be allowed by their governments to return to work and daily life in ways similar (if at all) to that prior to the crisis — which may lead to new waves of infections and deaths. Much psychological tension/stress has, accordingly, been associated with this pandemic.

Although much of the world is being dramatically affected by an entity (coronavirus, as in Figure 1) that thrives by commandeering ‘machinery’ of living beings (cells) to propagate itself, such cooption seems somewhat ‘normal.’ Indeed, this crisis, with perhaps more to come, has been previously-experienced, seems greatly anthropogenic and long-predicted; and, yet, in many sociopolitical jurisdictions, active responses to it have been ‘uneven.’ Such variations in responses suggest, accordingly, that ideological battles will be waged surrounding the nature of ‘normality’ that societies will support after this crisis subsides.

Given their prominence in societal priorities and practices, this article focuses — after a critical review of features of our ‘pre-CoViD-19 pandemic’ world — on possible and perhaps necessary effects on education in science and technology of the CoViD-19 crisis and other threats. A paradigm ‘battle’ seems necessary!

Figure 1: Coronaviruses (blue) and Human Cells.

Our ‘Normal’ World

Particularly for about the last 50 years, much of the world has been experiencing numerous crises that can be linked to fields of science and technology. As Greta Thunberg, a teenaged activist from Sweden, said to delegates at the annual gathering of world financial and political elite in Davos, Switzerland, in January 2019 (and, again, in 2020), “Our house is [still] on fire!”² Climate disruption is escalating at such a pace, in other words, that she said we need to treat it not as a ‘risk’ or controversy, as she said many politicians and other leaders were doing; but, like an emergency that is equivalent to imminent destruction of our homes. In making

¹ The ‘CoViD-19’ pandemic is linked to the SARS-CoV-2 virus. For nature and extent of this pandemic, refer to: <https://covid19.who.int> (also see: <https://coronavirus.jhu.edu/map.html>).

² <https://www.theguardian.com/environment/2019/jan/25/our-house-is-on-fire-greta-thunberg16-urges-leaders-to-act-on-climate>; <https://www.theguardian.com/business/2020/jan/21/greta-thunberg-calls-on-world-leaders-to-heed-global-heating-science-davos>

such a dramatic statement, Ms. Thunberg could be echoing advice from Noam Chomsky³, who said — as also recently stressed by the Bulletin of the Atomic Scientists⁴ — humanity is facing at least two *existential* threats; that is, devastation from nuclear war and from climate disruption (also see: Ripple et al., 2020). At the same, among myriad other harms, it is apparent that humans continue to be plagued by ongoing illnesses associated with manufactured foods (Weber, 2009), pharmaceuticals (Norman et al., 2011) and tobacco (Verma, 2009); and, industrial activities are severely compromising many eco-spaces — contributing to what many suggest is our current (6th) period of mass extinction (Moore, 2016).

Blame for crises like those noted above could be aimed at various sources. Based on *actor-network theory* (Latour, 2005), it may be that responsibility should be *distributed* across a network of all living, nonliving and symbolic entities (‘actants’). In that vein, Haraway (2016) suggested that humans are immersed in a *Chthulucene* (earthly) epoch — positing agency of nonliving (as well as living) entities. *Equal* distribution across such material-semiotic networks appears, however, unlikely. While acknowledging agency of myriad abiotic entities, many analysts claim that most global problems would not exist or would be much less severe without human influences (e.g., Jasanoff, 2015) — and, therefore, suggest that we have been suffering through an *Anthropocene* epoch (Crutzen & Stoermer, 2010). Indeed, Foucault (2008), for instance, suggests that some actants are able to influence many others to, more or less, align their purposes and actions — referring to such cooperating assemblages of actants as *dispositifs*. In this regard, many scholars and others suggest few actants rival influences of *pro-capitalist* individuals (e.g., financiers) and groups (e.g., corporations, transnational trade organizations, think tanks) (e.g., Hardt & Negri, 2009). Accordingly, major responsibility for our numerous personal, social and environmental harms may best be aimed at *pro-capitalist* actants — thus suggesting we are currently dominated by what may be called the *Capitalocene* (Patel & Moore, 2017).

Although capitalism has operated since about the 17th century, its activities and reach have dramatically accelerated since the early 1970s — with rapid development of its ‘neoliberal’ variant. In contrast to earlier forms, *active* support from governments, transnational socio-economic organizations, think tanks, universities, etc. have facilitated infusion of capitalist ideals, such as possessive individualism, competitiveness, externalization of costs/responsibilities and socio-economic stratification, across myriad living, nonliving and symbolic entities on a global scale (Harvey, 2005; Springer, Birch & McLeavy, 2016). The resulting entity, which seems not unlike The Borg™ from the Star Trek™ entertainment series and, more formally, may be thought of as a giant multipart *dispositif*, appears capable of assimilating most entities into its networks. Indeed, as a complex and far-reaching network of actants, the capitalist *dispositif* tends to be extremely resilient — very difficult to disentangle. Rather than struggling with crises, for example, it seems to *thrive* on them. After the Global Financial Crisis of 2007-08, for instance, it apparently adapted and emerged even stronger. It may, for example, have contributed to recent and rapid emergence around the world of so-called *right-wing populism* (Mouffe, 2019; Rodrik, 2018). Although definitions vary, this often seems to feature movements in which charismatic leaders — like US President Trump — claim to be ‘saviours’ of common people within nation states, many of whom have struggled financially under neoliberal capitalism (e.g., austerity measures following the 2007-08 financial crisis), against ‘evil’ elite (e.g., traditional government

³ https://www.democracynow.org/2019/4/12/chomsky_nuclear_weapons_climate_change_the

⁴ <https://thebulletin.org/doomsday-clock/current-time/>

members and experts). However, aligned with Naomi Klein's (2007) concept of *disaster capitalism*, such leaders often use public disorientation, anxiety, fears, etc. to enact *states of exception* (Agamben, 2005) — e.g., overriding existing laws meant to protect citizens and environments — to further enact policies and practices to benefit socioeconomic (and other) elite through tax reductions for rich, (de-)regulation of businesses to maximize profits, often at expense of wellbeing of most individuals, societies and environments, denial or suppression of science (e.g., about climate changes) that could challenge traditional for-profit enterprises (e.g., petroleum-based industries), privatization of public services and much more (Rodrik, 2018).

As with disaster capitalism, a common tack in successes of various capitalist forms has been — and, apparently, continues to be — *subterfuge*. Particularly in 'democratic' states where control of populations through military force is less prominent (Gramsci, 2003 [1971]), elite may control masses of people through 'educational' actions that can contribute to individuals' development of subjectivities regarding identities, attitudes, orientations, etc. that they may believe are best for them but may distract them from awareness of exploitative activities enacted by capitalists (Foucault, 2008). Although it is not necessarily causal, such subterfuge may work because many (or most) citizens have been conditioned to regularly develop identities and accommodate behaviours based on repeating cycles of consumption and disposal of products and services that are attractive to them because of various positive semiotic messages associated with them that can, like a Trojan horse, distract consumers from awareness of often hidden negative relationships with the products/services (Bencze & Carter, 2015). Playing prominent roles in such subterfuge appear to be fields of science and technology. This can be understood with reference to Figure 2. It is adapted from Roth's (2001) schema for depicting reciprocal relationships between 'science' (World → Sign) and 'technology' (and engineering) (Sign → World) — which, due to influences on each other, may be called 'technoscience' and, with mathematics often involved in both, also can represent STEM (Science, Technology, Engineering & Mathematics) fields. Key to 'STEM' fields' contributions to subterfuge used in consumerism appear to be the

Figure 2: Phenomena ↔ Representation Translations.

‘gaps’ in translations between World and Sign. Common — largely unavoidable — sets of problems, as Roth (2001) noted, are *ontological* gaps; that is, inconsistencies in translations between World and Sign due to differences in composition (ontologies) of entities (e.g., geographic areas [World] vs. maps of them [Signs]). Much more avoidable, however, are *ideological* gaps; that is, *intentional* inconsistencies in the translations (Bencze & Carter, 2015). It has long been felt that, for example, scientists may try to ‘sell’ their ideas — using different techniques — to influence readers’ interpretations of their data and arguments (Latour & Woolgar, 1986). Particularly problematic, however, seem to be influences of capitalists on STEM work. There is much evidence to suggest that for-profit products are sold more in terms of semiotic messages they may portray than their qualities, uses, etc. With reference to Figure 2, there may be such substantial ideological gaps between a product in the World (e.g., makeup) and advertising (Signs) about it that such representations may be said to be *hyperreal*; that is, while appearing to represent the real entity (makeup), may be, actually, a false construction of it (Baudrillard, 1998). Based on numerous studies of STEM research and publication, however, it appears that there are myriad adverse effects relating to World $\leftrightarrow$ Sign relationships with capitalist involvement in goals, research approaches, data processing, publishing, etc. (Angell, 2004; Kleinman, 2003; Krimsky, 2019; Mirowski, 2011; Ziman, 2000). A clear example in recent years pertains to different approaches for hiding or minimizing apparent anthropogenic contributions to climate disruption (e.g., via CO₂ releases from petroleum combustion) (Klein, 2014). Associated with right-wing populist governments in recent years, moreover, have been extreme adverse capitalist influences on STEM fields. The Union of Concerned Scientists reported the US Trump administration had implemented a vast and diverse set of problematic, pro-capitalist, policies and practices, including: Sidelineing independent science advice; Leaving key science positions vacant; Revoking science-based safeguards; Misrepresenting climate science and rolling back climate change safeguards; Weakening science-based pollution standards without scientific justification; Undermining protections from hazards at work and home; Altering scientific content on federal websites; Reducing public access to data; and, Creating a hostile environment for scientific staff (Carter et al., 2017). Two years later (Carter et al., 2019), such (a)bususes of STEM fields appeared to be even more extensive and problematic.

Overall, complex and adaptable pro-capitalist networks appear to have served capitalists quite well. Piketty (2020), for instance, suggests that capitalism has been intensely concentrating wealth throughout the neoliberal period and, moreover, seems destined to continue to do so at unprecedented rates — largely at expense of many other humans, other living things and nonliving environments. Oxfam (2020), for example, claims that: about 2,153 billionaires now have about the same total wealth as approximately 4.6 billion people; the richest 1% have more wealth than 6.9 billion people; and, almost half of the world’s population live on less than \$5.50 (USD) a day⁵. Such wealth concentration appears to be coinciding with ongoing or increasing personal, social and/or environmental degradation — such as those noted above.

Dreaming of an Ecosocialist Utopia

If state capitalism is a major — if not *the* — root of most personal, social and environmental problems in our current epoch (and for the foreseeable future), it seems clear that, rather than reforming it, it must be

⁵ <https://www.oxfam.org/en/press-releases/worlds-billionaires-have-more-wealth-46-billion-people>

replaced (e.g., Hardt & Negri, 2019; Loewenstein 2015; Löwy, 2015; Piketty, 2020). Given its resilience, however, such revolutionary change will not be easy. Nevertheless, there are hopes for massive transformation. In our recent *pre*-COVID-19 era, there have been significant indications of considerable political instability around the world — with many citizens amenable to relatively rapid cultural and economic change (Dalton, 2018). A key question, however, could be, ‘What sorts of sociopolitical and economic systems should replace capitalism?’ Some form of *socialism* — being antithetical to capitalism — seems an obvious choice. However, many ‘socialist’ states, such as the former USSR, have been highly *authoritarian* (Borgnäs et al., 2015). This seems problematic, given that many of the harms noted above have arisen from ‘facilitated’ capitalism; that is, *neoliberalism*. Instead, theorists have recommended societies accommodate more *anarchical* forms of socialism. Chomsky (1999), for example, promotes *libertarian socialism* — preferring democratic decision-making by small groups of community members (as *socialism*), free from influences of hierarchical governing bodies (as *libertarianism*). Meanwhile, in light of alarming environmental devastation (e.g., as noted above) associated with neoliberal capitalism, many theorists have stressed needs for combining strong environmental ethics with possibilities for a more socialist world (Saito, 2017). In this vein, many theorists have urged shifts towards more *eco-socialist* societies; that is, non-capitalist societies that prioritize values like: equity, diversity and environmental vitality and resilience⁶ (Borgnäs et al., 2015; Kovel, 2014; Löwy, 2015; Wallis, 2018).

Lest reformers be guilty of oppression by trying to impose their conception of a utopic — perhaps eco-socialist — society, such change must be conducted *democratically*, involving successive critical reflective practices (praxis) engaging many (if not all) stakeholders (McLaren, 2000). While acknowledging that such a prudent tack may not yield ‘fully-planned’ eco-socialist societies, it still may be worth *dreaming* of such worlds. Indeed, it is apparent that “[t]he great milestones of civilization [e.g., ‘elimination’ of slavery] always have the whiff of utopia about them at first” (Bregman, 2017, p. 42). In light of successes of capitalism through assemblage of dispositifs, it seems that visions of its replacement are likely to require *multi-pronged actions* — all, more or less, aimed at achieving cooperation among myriad actants for such ideals as equity, diversity and environmental health. This recommendation aligns well with calls from those, for example, who recommend we replace our conceptions of humanity as *Homo aeconomicus* (highly rational, self-interested, individuals). We could, for instance, broaden economics beyond foci on Gross Domestic Product to include attention to basic human needs like food and shelter and global environmental conditions like atmospheric Greenhouse gas concentrations (Raworth, 2017); and, we could acknowledge and celebrate human emotions — prioritizing, for instance, orientations towards communitarian care (Lent, 2017).

Dreams for development of paradigm-changing assemblages (eco-socialist or otherwise) may be guided by so-called *socio-technical imaginaries*; that is, “collectively held, institutionally stabilized and publicly performed *visions* of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology” (Jasanoff & Kim, 2009, p. 4; italics added). Rather than ideals, values, principles, etc. that are prioritized in capitalist dispositifs, such as individualism, competitiveness, costs externalization, etc., we might imagine and widely promote assemblages largely valuing principles like: equity, diversity, communalism, collaboration, needs-based production, ecological harmony,

⁶ See, for example: <http://environment-ecology.com/political-ecology/428-eco-socialism.html>

shared responsibilities, community-based decision-making (regulation) and shared ownership of production and consumption.

A Paradigm ‘Battle’ Precipitated by Crisis

Apart from government-sponsored social programmes (e.g., for health and old age and promotion of unionization for workers) that were prioritized for about 30 years after the Great Depression and World War II, shifts towards more eco-socialist systems has been frustratingly slow. Even in the face of threats like the global financial crisis of 2007-08, wellbeing of capitalists, more so than the ‘general public,’ have been prioritized. Chomsky (2017) suggests that governments (and other institutions) have — in responses to such crises — typically ruled in favour of capitalists, a phenomenon he says is *socialism for the rich and capitalism for the poor*. Suddenly, however, it seems we are experiencing a crisis perhaps posing more of an existential threat to capitalism (Klein, 2020a; Naughton, 2020). Within a few weeks of the World Health Organization (WHO) declaring (March 11, 2020) the CoViD-19 spread to be a pandemic, governments had instituted policies and practices that were, to a great extent, *unimaginable* under recent (e.g., neoliberal) conditions (Baker, 2020). Governments around the world — led by politicians from across the political spectrum — have quickly (and amazingly) ‘found’ funding for a range of *social* supports, including: increased health care services for infected individuals, financial relief for furloughed workers (e.g., construction labourers), small-business employers, students unable to obtain summer work, citizen income tax payment deferrals, postponed rent payments, research and development for a cure and much more. Meanwhile, coinciding with reductions in factory operations, commercial aviation, etc., *environmental* changes that may be associated with more eco-socialist government policies have occurred, including lower air pollution levels (Baker 2020) and greenhouse gas emissions (UN, 2020). There have, as well, been noticeable ‘psychosocial changes’ perhaps aligning with more socialist perspectives, such as people volunteering to help those in need (Solnit, 2009), some more globalist (rather than nationalist) conceptions of ‘citizenship’ (French & Monahan, 2020) and artistic expressions of community spirit⁷. Additionally, it is apparent that countries that had somewhat eco-socialist policies and practices prior to the crisis, such as South Korea, have had relatively few deaths from CoViD-19 (Davis, 2020; French 2020; Galloway, 2020; Kim, 2020; Wintour, 2020). Meanwhile, countries with weaker social systems, especially regarding health care and pandemic preparedness, tended to struggle with it — resulting in some wryly suggesting that such countries may have done better with the disease if they had prepared for viral attacks to the same extent as they prepared for military ones (Roy, 2020).

At this ‘point’ (late June 2020) in the CoViD-19 pandemic, those (like me) in support of eco-socialist policies and practices may be heartened by changes like those noted above associated with the crisis. They might, however, heed warnings from Naomi Klein (2020a), who suggested that capitalists are likely to try to exploit this virus crisis, as they have done previously, to further implement neoliberal policies and practices. Adapting her concept of disaster capitalism (Klein, 2017), she suggests we may face *coronavirus capitalism*.

⁷ At YouTube™ (<https://www.youtube.com/>), add: watch?v=erDu63SEJXI; watch?v=Gnh6KTj84S8; watch?v=2xWUL4N26vM; watch?v=CDdxXL6fdwA; and/or, watch?v=OkIhBgQAw3U

“Ideas that are lying around” — (Milton) Friedman, one of history's most extreme free-market economists, was wrong about a whole lot but he was right about that. In times of crisis, seemingly impossible ideas suddenly become possible; but, *whose* ideas — sensible, fair, ones designed to keep as many people as possible safe, secure and healthy, or predatory ideas designed to further enrich the already unimaginably wealthy while leaving the most vulnerable further exposed?⁸

Others have echoed this fear. Smith and Holden (2020), for instance, suggest the virus crisis is acting like a ‘perfect’ storm causing public destabilization that is enabling pro-capitalist leaders like US President Trump to enact changes like: massive, no-strings-attached, bail-outs for financiers and corporations, de-regulation of often problematic (e.g., petroleum-producing/consuming) businesses, appointment of Right-wing supreme court judges and further isolating the USA from other countries (e.g., further immigration controls and border securitization) (also see: Holland & Beach, 2020; Pearl & Lazonick, 2020). Perhaps one of the changes relatively acceptable to ‘the public,’ given clear importance of identifying infected people and keeping others safe, are increases in citizen surveillance (Nimmo, 2020; Roth et al., 2020). This could, in light of warnings from Zuboff (2019) about *surveillance capitalism*, lead to increased for-profit electronic monitoring and biopolitical subjectification of humans and other actants. Also, perhaps well-meaning frequent government advice to populations about self-care and care of others (e.g., wearing of masks) has contributed to individualism that is linked to neoliberalism (French & Monahan, 2020).

Although the CoViD-19 pandemic appears to have allowed some anti-neoliberal phenomena to emerge, neoliberalism has not been ‘killed’ off by the crisis. Indeed, there appears to be a spectre of *zombie capitalism* (Harman, 2010) — a sense that (neoliberal) capitalist ideologies, individuals, groups and practices are ready to resume dominance of societies once that has been wrestled from the ‘hands’ of coronaviruses. Beyond signs of their resurrection like those noted above, there are apparent risks that, for example, large pharmaceutical companies will limit people’s access to tests and vaccines because of corporate patents (Darzi, 2020). This seems to align with views that capitalist instincts (and infrastructures) are well-entrenched in societies (Gliniecki, 2020) and that, in addition to selling dreams of better futures, capitalists often are willing to profit from *suffering* (Loewenstein, 2015). Perhaps most importantly, pro-capitalist governments — including those labelled Right-wing Populists (e.g., in Brazil, Hungary, India and the USA) — and pro-capitalist transnational organizations (e.g., World Bank, 2020) are poised to reignite ‘engines’ of capitalism as soon as possible, in many cases, prior to development and widespread availability of an effective vaccine against the SARS-CoV-2 virus (Wilson, 2020).

In light of socio-political phenomena like those noted above, it seems clear that the CoViD-19 pandemic has precipitated a particularly volatile *ideological* battle that could change societies for the foreseeable future. Of particular importance, given their influences on many societies, are struggles between those who would urge governments to take active roles — and considerable taxpayer-supported economic inputs — in promoting equity, diversity, harmony and vitality across populations and environmental health and resilience and those who would have governments prioritize individual responsibility, competitiveness and entrepreneurship that tend to favour wellbeing of relatively few societal members, often at expense of wellbeing of most other living things and nonliving environments (Varoufakis & McWilliams, 2020). Avoiding

⁸ <https://www.youtube.com/watch?v=niwNTI9Nqd8&t=20s>

the latter set of priorities and practices, which seem destined to promote social injustices and environmental degradation, will require vigorous and sustained public engagement (D'Eramo, 2020; Žižek, 2020).

Hopes from Critical and Altruistic Science & Technology Education

Given roles in capitalists' gains — and associated personal, social and environmental harms — played by fields of science and technology and by science and technology education, the latter which often have helped generate workers (at various skill levels) to develop and manage means of production and masses of compliant workers and enthusiastic/unquestioning consumers (Giroux & Giroux, 2006), it seems clear that a major site for development of informed and well-engaged community members may be science and technology education (Hodson, 2011; Roth & Désautels, 2002; Santos, 2009). Indeed, it seems government curricula in different countries have included provisions for such education. 'Science-in-Context' (SinC) aspects of curricula (Bencze et al., 2020), such as those regarding *socially-acute questions*, *socioscientific issues* and (relationships among fields of) *science and technology and societies and environments* (STSE), encourage multi-disciplinary education that could enlighten students about adverse effects of influences of powerful people and groups on fields of science and technology and motivate them to engage in social actions to overcome harms. On the other hand, such SinC curriculum mandates are not extensively implemented. In practice, for instance, most (although not all) generally avoid promotion of civic actions — instead prioritizing neoliberalism-friendly logically-reasoned personal choices about controversies (Levinson, 2013; Sjöström et al., 2017). Perhaps more worrisome, it is apparent that such mandates tend to be *avoided* — with school science systems focusing, instead, on teaching/learning of reductionist 'achievements' — such as laws, theories and inventions/innovations — and confirmatory methods of fields of science and technology. A governing ideology seems to have been that school science promotes learning of what *is* (e.g., current widely-accepted conceptions of phenomena), rather than also about what *ought* to be (e.g., changes in government regulations that may improve products of science and technology) (Levinson, 2018). Indeed, this tendency appears to have been *intensifying*. Despite their stated promotion of integration and/or interrelationships, many 'STEM' (Science, Technology, Engineering & Mathematics) education initiatives — which have dominated much of science education in about the last decade — tend to, ironically, *omit* references to SinC fields, such as history, philosophy and sociology, and limit extents to which students may engage in socio-political actions to challenge existing systems (Bencze et al., 2018; Hoeg & Bencze, 2017; Zeidler, 2016). Designers of STEM education initiatives tend, in other words, to emphasize teaching/learning of reductionist conceptions of the four fields, focusing mainly on techniques and their widely-accepted products, in a process that Callon (1991) referred to as *punctualization*; that is, making a complex system appear much simpler than it likely is in reality. Missing elements in such reductive processes in STEM education tend to be those that would — if made more public — make the four fields seem problematic and, in turn, cast negative lights on their financial backers, thus causing disenchantment among populations that may lead them to mobilize for a more just and sustainable world (Pierce, 2013). Many STEM initiatives are, in other words, also greatly *de-problematized*.

Although STEM education initiatives vary, their punctualized and de-problematized curricula seem to prioritize identification and education of relatively few professionals and technical workers in STEM fields who may develop and manage production and marketing of for-profit products and services that may assist

businesses to successfully compete in a ‘neo-Sputnik’ era in which, for example, companies based mostly in North America compete against those in Asia and Europe (Pierce, 2013). Such a hierarchical conception of society seems reflected, for example, in plans for the latest national science curriculum in the USA:

The primary driver of the future economy and concomitant creation of jobs will be innovation, largely derived from advances in science and engineering. . . . [Four] percent of the nation’s workforce is composed of scientists and engineers; this group disproportionately creates jobs for the other 96 percent (NRC, 2011, p. 2).

In light of the above discussion, it seems clear that educational programmes are needed that may enlighten students about sometimes problematic relationships among fields of science and technology and powerful societal actants and, where they perceive harms, help them to develop expertise, confidence and motivation to develop and implement personal and social actions that may overcome them — and, thus, contribute to transition of societies towards those that place more priority on such values as equity, diversity and environmental wellbeing. A

framework showing promise in this regard is STEPWISE⁹ (Bencze, 2017). As illustrated in the upper right of Figure 3, this is a schema that organizes teaching/learning goals (e.g., “Skills Education”) in a way that encourages students to, *altruistically*, ‘spend’ some of their sociocultural capital (Bourdieu, 1986) (e.g., “STSE Education”) on trying to improve the world through “STSE Actions.” This goal is meant to contrast sharply with perspectives and practices that perceive education (including in science) as a competition for limited cultural and social capital and, instead, prioritizes *communitarian* values. Such a goal may help combat post-CoViD-19 pandemic efforts by pro-capitalist forces that would work to limit wellbeing to those successful in socio-economic (and other) competitions.

Although the tetrahedral version of STEPWISE (upper right,

Figure 3 : STEPWISE Schema & STSE Relationships.

⁹ To learn more about STEPWISE, visit: www.stepwisser.ca

Figure 3) is based on educational philosophy and research, teachers' initial difficulties with it led to development of the more pragmatic, sequential, version given at the bottom of Figure 3. This arrangement suggests that teachers first provide students with 'apprenticeship' lessons and student activities that may *eventually* enable and motivate them to *self-direct* 'research-informed and negotiated action' projects ("Students' Self-led RiNA Projects") to address harms that they identify in STSE relationships. Accordingly, as well as being research-informed, students' negotiated social action choices should be based on sound and comprehensive education. Depending on factors like students' ages, abilities and stages of learning, 'apprenticeships' may consist of one or more constructivism-informed cycles involving each of the following three phases:

1. Students Reflect: The teacher may provide students with 'stimuli' (e.g., commodities, like cell phones, associated with science and technology) that may encourage students to 'express' (e.g., via discussions, drawings, models) their current attitudes, skills and knowledge ('ASK'), etc. regarding STSE relationships (including actions people might take to address harms in them). Such ASK — regardless of them often differing from scientists' and engineers' claims and products — should be valued by teachers, hoping to increase student self-esteem and motivation to learn and act;
2. Teacher Teaches: Particularly because students are unlikely to discover them through their own inquiries (Bencze & Alsop, 2009), it is recommended that the teacher *directly* teach important (e.g., roles of transnational corporations) and diverse (e.g., Indigenous knowledge) ASK in STSE relationships and examples of RiNA projects (refer below) to address harms in them. To consolidate such taught ASK, however, teachers also are urged to engage students in relevant *application* activities — such as instructions and questions about STSE and RiNA documentaries; and,
3. Students Practise: To deepen and more personalize students' expertise, confidence and motivation for them, the teacher encourages students to develop and implement small-scale RiNA projects to overcome harms in STSE relationships identified by students. Projects are mostly student-led, but the teacher may assist some students, in different ways, depending on students' needs and requests.

Once the teacher feels that students are able to do so, they then may be asked to 'self-direct' (within limits of school assessment practices) educated RiNA projects to address harms they perceive (and have interests) in STSE relationships — such as government-corporate facilitation of non-biodegradable beverage cups.

Our research since about 2006 with science educators in formal primary, secondary and tertiary education contexts and in after-school clubs indicate that the schema at the bottom of Figure 3 has helped many students to develop significant expertise, confidence and motivation for self-directing (mostly) varied and personally-meaningful RiNA projects (Bencze, 2017; Bencze & Alsop, 2014). Such successes suggest that the STEPWISE framework may be useful for ceasing opportunities generated by the CoViD-19 pandemic for encouraging and enabling students — as current and future community members — to analyze and critique STSE relationships and, for harms they determine, develop and take social actions to overcome them. Such an education may, broadly, contribute to efforts to transform societies into those giving greater priority to social justice and environmental wellbeing.

Based on past successes with promotion of RiNA projects, it is apparent that students may contribute to social transformation in at least two broad (co-affecting) ways; that is, as depicted in Figure 2, regarding World $\leftrightarrow$ Sign translations:

Proposed Changes. Perhaps as expected in school *science*, many student RiNA projects prioritize science research (World → Sign translations) — while also making *recommendations* for (rather than actualization of) translations from Signs → World. As shown in Figure 2, for example, a student’s research led to an actor-network map illustration of social-technical relationships involving liquid foundation make-up which, in turn, led her to develop a related educational video (tinyurl.com/vdfey3y) that could influence numerous actants — including friends, family, members of the general public, government officials and others. Her video perhaps had much narrower ideological gaps with her actual makeup than that which may be typical in cosmetics companies’ advertising. Several other such examples can be found in two special issues of *JASTE*: tinyurl.com/y9axcbou; and, bit.ly/2JGIgtf. With perhaps further insights from teachers (*Teacher Teaches*, lower section of Figure 3) about long-standing (e.g., in the neoliberal period) adverse influences of capitalists on integrity of STEM research and publication (Krimsky, 2019) and more recent possibly dramatically-increased adverse influences by right-wing populist governments (Carter et al., 2017, 2019), students may provide governments, transnational pro-capitalist organizations, think tanks, general members of the public, etc. with recommendations for increasing integrity and uses of STEM work.

Actualized Changes. Apparently, not so common in school science have been technology design projects (Sign → World, Figure 2). Although recommended in many school science/STEM initiatives (Pleasant & Olson, 2018), these tend to (refer above) punctualize and de-problematize STEM processes, products and their dissemination (Bencze et al., 2018; Pierce, 2013). Accordingly, for the last few years, graduate students, teachers and I have been conducting action research to explore potentials in encouraging and enabling school science students to develop, implement and promote ‘WISE’ technology designs; that is, innovations or inventions that perform desired tasks and promote social justice and/or environmental wellbeing outcomes. Education of students prior to their development of ‘WISE’ technologies involved instruction about problematic STSE relationships (including through uses of actor-network maps), such as those noted above about consumerism. In doing so, students also were introduced to problems linked to compromises that may be made (intentionally or otherwise) in technology design. As shown in Figure 4a regarding design of a ‘WISE’ tent, for example, although uses of hydrophobic chemicals may be effective in water-proofing the tent, they may be toxic — a compromise people and/or groups (e.g., corporations) may be willing to allow, perhaps for the sake of profit. Among student technology designs, a student with particular concerns around social justice (and

Figure 4a: ‘WISE’ Technology Design: Compromises.

environmental wellbeing) chose to design (and re-design) and build, using many recycled ('waste') materials, a candle recycler — as illustrated in Figure 4b — that he said could be useful to people without electricity. For other such designs, see *JASTE*, 11(1) at: tinyurl.com/yb45cbmv.

Although most students have been able to design and implement WISE technologies and were aware (mostly *during* design, rather than prior to it) of various compromises, most limited their approaches to establishing larger, more complex, networks (dispositifs) for their innovations/inventions to 'Likes,' etc. from their 'followers' in their social media environments (e.g., Instagram™). In the context of formal schooling, it seems difficult for many (or most) students to rally — to extents similar to that of capitalists, for example — numerous actants in support of their causes (e.g., WISE technologies). Consequently, it appears more action research is needed in this regard.

Although STEPWISE has been relatively successful in ways suggested above, it seems to be limited to contexts in which co-supportive actants (a dispositif) exist — including, for example: an enthusiastic and appropriately-educated (e.g., about capitalist influences on STEM fields) teacher; supportive colleagues and school administrators; official curricula sanctioning such perspectives and practices (MoE, 2008); appropriate instructional resources; understanding parents; and, perhaps, mentorships by one or more action research facilitators (Bencze & Krstovic, 2017). Accordingly, efforts to use pedagogical frameworks like STEPWISE to contribute to social transformation — perhaps more aligned with eco-socialist principles — is likely to require concerted, multi-pronged, actions to encourage assemblage of supportive dispositifs.

Coda

Coronaviruses — like human capitalists — have commandeered 'machinery' of living (and non-living) things to serve their purposes while disregarding wellbeing of many biotic and abiotic entities. Coronaviruses as capitalists appear to be different from human ones in some important ways, however. Although both seem highly self-serving, the inanimate (viral) form seems somewhat more indiscriminate in entities it harms. Coronaviruses have caused considerable sickness and death among advantaged humans, and have severely curtailed much of their business activities — limiting for-profit contributions, either temporarily or permanently (via death), of many of their workers. In doing so, the CoViD-19 pandemic appears to have quickly disaggregated previously tightly-assembled capitalist dispositifs. At the same time, it has *de-punctualized* capitalist dispositifs; that is, like opening of a virtual 'black box,' more people may become aware of inner

Figure 4b: 'WISE' Technology Design: Sample Design (Candle Recycler).

workings of pre-CoViD-19 socio-economic infrastructures. They may, for instance, gain critical consciousness of ‘immunity’ that some people have — which others lack — from socioeconomic struggles under capitalism (Preciado, 2020). Among the most startling insights in this regard, however, appear to be sudden ‘altruistic’ behaviours — in terms, for instance, of massive and unusual increases in funding for health care, ‘essential’ labourers,’ the unemployed, etc. — of governments seems particularly clear. Beyond that, people also may have been sensitized to *re-naturalization* of some urban spaces — such as sightings of wild animals on city properties and general pollution reductions — and increases in citizen acts of kindness, such as work by numerous people to care for disadvantaged others. Within a few months, in other words, spectres of eco-socialist-leaning worlds may be in view for many people.

For many theorists and others, the CoViD-19 pandemic represents an unprecedented opportunity for societies to urge governments to take more active roles in serving the broader citizenry and local/global environments — rather than just privileged few at expense of wellbeing of most citizens and environments. As argued here, of particular concern are problematic effects of influences of neoliberal capitalist dispositifs — prompting numerous calls for their replacement with sorts of socio-economic systems that prioritize social justice and environmental wellbeing (Anthony, 2020; Baker, 2020; Borger, 2020; Dufresne, 2019, 2020; Letwin, 2020; Piketty, 2020; Varoufakis & McWilliams, 2020; Žižek, 2020). Although I have suggested here that coronaviruses are like capitalists, exploiting — at pandemic levels — available infrastructure to serve their ends regardless of resulting harms, an alternative view (while in a similar spirit) is that capitalism is, as suggested by recent graffiti (Figure 5), the (ongoing) pandemic. Like the disease, capitalism (neoliberal or otherwise) appears to have contributed to massive hardship and destruction and, therefore, must be replaced. Indeed, given harms

Figure 5: Coronavirus and Capitalism.

Figure 6: Mesopotamian god vs. Gryphon, c1,000BCE.

it appears to have caused, scholars like Ord (2020) have called for its rapid elimination, suggesting we are on a ‘precipice’ regarding numerous existential risks and, without immediate actions, we will be guilty of continuing to colonize our descendants (at least) with this fundamentally psycho-/socio-pathic system (Bakan, 2004). Add to this Latour’s (2020) point that spread of the SARS-CoV-2 virus has both supported his contentions surrounding global actor-networks — which he and colleagues suggest is not unlike the *Gaia* concept of Earth (Arènes, Latour & Gaillardet, 2018) — and provided inspiration for global distribution of pro-ecosocialist messages.

Those wanting to ‘capitalize’ on opportunities ‘presented’ by the CoViD-19 pandemic can expect an epic battle (metaphorically depicted in Figure 6) against neoliberal capitalist ‘forces.’ Although financiers and corporations (and their supporters, such as some government officials) have experienced perhaps an unprecedented set-back, capitalist ideology is unlikely to have ‘died’ and, related to this, state capitalism appears ready — and, indeed, already active — in reviving, if not massively expanding, capitalist activities and outcomes. As advised by Naomi Klein (2007, 2020a,b), many pro-capitalist governments, financiers and corporations and others are using general ‘dis-ease’ associated with the pandemic (French & Monahan, 2020) to further implement such policies and practices as non-repayable bail-outs for companies ‘too big to fail,’ deregulation of many often harmful businesses (e.g., using petroleum) and, perhaps most *easily* (e.g., for citizens’ own protection), increases in public surveillance to further ensnare and manipulate myriad living, nonliving and symbolic entities (French, 2020; Gliniecki, 2020; Klein, 2020b; Loewenstein, 2015; Nimmo, 2020; Pearl & Lazonick, 2020; Roth et al., 2020).

Ultimately, as in the past, struggles between supporters of capitalism and their opponents will be *ideological* (Piketty, 2020); that is, value-centred decisions — a major example being *hypercapitalism*, which may mean:

our willingness to believe billionaires have earned their money, that their philanthropy offsets their greed, that most of the poor are ‘undeserving’, and that any tinkering with the present distribution of wealth will lead to economic collapse (Mason, 2020).

Piketty’s (2020) focus appears, in other words, to be on contestation of ideological (non-)support for assemblage of pro-capitalist dispositifs. Given roles of fields of science and technology in them, it follows that their educational counterparts may be complicit in helping citizens to navigate such ideological battles.

In this article, I suggest that the STEPWISE framework for science and technology education can contribute to efforts to educate students about controversial and possibly-problematic relationships among fields of science and technology, generally, and, more specifically, about ideological struggles raised by the CoViD-19 pandemic between supporters and opponents of state-sponsored capitalism and, to help students to develop expertise, confidence and motivation to develop and implement actions to address harms they perceive in such relationships. STEPWISE has had some successes in helping students to develop and implement such social actions. However, because the CoViD-19 pandemic appears to have disrupted, depunctualized and problematized dominant socio-economic systems to extents not seen in recent years and, perhaps, unlikely to have occurred through previous mainstream socio-political actions, science and technology educators may have *unprecedented* opportunities — and, given associated harms, *responsibilities* — to educate students about possibly-problematic relationships among fields of science and technology and societies and environments. Students could be taught, for example, about many ways neoliberal capitalism appears to have adversely influenced many aspects of STEM work (Krimsky, 2019), along with different ideological positions behind so-called coronavirus capitalism that Naomi Klein (2007, 2020a,b) suggests could be a particular problem for wellbeing of individuals, societies and environments. In that vein, they might be taught that the coronavirus release (presumably from the wild) was perhaps anthropogenic and/or, indeed, linked to capitalist incursions into natural settings and influences on some governments to limit preparedness for such pandemics (Foer & Gross, 2020; Johnson et al., 2020; Letwin, 2020; Ord, 2020; Weston, 2020; Žižek, 2020). As well as making recommendations to governments, corporations, members of ‘the public,’ and others about such phenomena, they may design, implement and attempt to mobilize technologies (work to establish

dispositifs supporting them) that both perform desired functions and attend to matters of social justice and environmental wellbeing (Wainwright, 2020).

Those hoping for movements towards more eco-socialist worlds may need to temper their optimism in light of significant inertia for ongoing over-whelming influences of pro-capitalist ideologies. Besides relatively-clear examples of ways in which capitalism has not been entirely suppressed during the pandemic, there is evidence and argument to suggest that, for instance, human brains have evolved since about the Enlightenment and Industrial Revolution periods to emphasize more particularized, rationalist, thinking apparently associated with the left hemisphere of our brains — at expense of capacities for wisdom, empathy, altruism, etc. associated with our right hemisphere (McGilchrist, 2009, 2018). As well, given strong influences of the virus crisis on our (dis-)comfort with person-to-person contacts, it seems that there are likely to be many more opportunities for education and other social relations to be mediated by electronic technologies (Greene, 2020) — many of which tend to be facilitated by public-private partnerships (Tam & El-Azar, 2020), which may be less-inclined to support educational forms critical of pro-capitalist regimes. Nevertheless, there are several indicators to suggest room for optimism regarding shifts towards more eco-socialist worlds. Naughton (2020) suggests, for instance, that the pandemic has had such profound effects on (essentially) state-sponsored capitalist dispositifs that there is no going back to normal; ‘the train has left the station.’ D’Eramo (2020) adds, for instance, that — unlike other crises, such as the post-World War II period — this crisis does not require significant infrastructure re-building, which could have been used by capitalists to capture greater amounts of public funds and further threaten environments through extraction and disposal activities. At the same time, it may be clear to voters that countries, like South Korea, that had strong pre-CoViD-19 health care systems and pandemic preparedness in place fared much better than those de-emphasizing such infrastructure. Add to this that over history and, perhaps particularly during crises, emergencies, difficult times, etc., people have repeatedly shown tendencies towards altruism (Bregman, 2020). Finally, academic educators, like myself, and others may be motivated to promote shifts towards more eco-socialist worlds through education because of calls for more politicized research and publication programmes through themes — despite its ironic placement near an extremely hyperreal theme park — like that for the 2021 annual conference of the *American Educational Research Association*: “The 2021 AERA Annual Meeting will be a place where attendees reject apolitical stances that limit how our scholarship affects societies¹⁰.”

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¹⁰ <https://www.aera.net/Events-Meetings/Annual-Meeting/2021-Annual-Meeting-Theme>

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Luddism, Isolation and Education

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Responses

JASTE is a non-refereed, open-access, journal. We encourage reader feedback on contributions to it. Please send your comments, suggestions, etc. about this paper to Emma McKay. Thanks!

Abstract. As the pandemic descended, even educators who resisted e-learning were forced to move their classes online. Undoubtedly, access to advanced communications technology has made all of this more bearable. Yet there are problems with technology. Some have more access than others, which further entrenches inequality in education. Surveillance provides only more power to the powerful. Luddism has for a long time offered a way to resist the unequal powers of technology through resisting the use of specifically those technologies which further inequality. Here, I offer a framework for Luddism that can be applied in the long term by educators and anyone else who seeks to build power in community.

Keywords: COVID-19 • educational technology • Luddism • place-based pedagogy.

Introduction

At the end of the 18th century in Britain, technology was introduced for looms which would automate the pattern created in the textile. Many textile workers were angry, as this lowered the value of their skilled labour. They started to break the machines, and fought for decades for their right to the living they had trained for. These were the Luddites: an organized, militant movement of workers fighting against a technology of capital (Hobsbawm 1964). As our world becomes more complex, power continues to accrue in the hands of the powerful through the way this complex technology orders the world. To boot, this tech is produced through a desire to provide the military with better tools and through mining, which accounts for at least 10% of global emissions annually. Technology is, in a nutshell, problematic. Neo-Luddism has evolved down many paths in response.

Today, we are all less able to see those we love, and have been reaching for technology more and more to stay connected. What do isolation and a pandemic mean for resisting technology? I hope to give something of an answer to this question here, first by exploring what Luddism is, and then by offering practical suggestions for Luddite approaches to technology in education during and after isolation.

Luddism

There are several strains of Luddism today within and outside of academia. A review of them is outside of the scope of this article—instead, I’d like to share what I mean when I say I aspire to be a part of a Luddite society.

The Luddism I seek does not aim to destroy technology. Rather, it starts with an understanding of what technology is: a (semi-)organized system or tool which shapes the world and what people can do in it. This definition is broad and includes everything from smartphones to paper voting systems to sewing needles. Technology is not inherently good or bad because it’s an incredibly broad category. Rather, the effect of a piece of tech is specific to that piece—we can ask where it comes from, what it was meant for, and what relationships it changes & how. This contrasts strongly with a technocratic approach to technology, which more or less assumes that complex technology holds the answers to our problems. In dominant discourse, it is often assumed that technology is good and useful, even when it further entrenches the hegemony of colonial capitalism (Lachney 2018, King 2016).

The materials for technology themselves are sourced from the ground of this one precious planet, often without consent of the people living in the area, and at immense cost to our climate and socio-biospheres (International Resources Panel 2019). A critical approach to tech understands this origin and aims to sustain life for a long time.

Luddism calls us to make our values clear in the decisions that we make about world-shaping tools. For many neo-Luddites, those values include being anti-technocratic, anti-capitalist, and pro-long-term-livability of our planet. We can include socio-ecological considerations in big decisions—what is best for all of us everywhere we are on this planet?

Rather than think of our world as technology-centred, we can think of it as problem-centred. We have a host of central issues that we must address in this life: health & access, food & water, communication, shelter, managing conflict, transit, art & entertainment, and knowledge production. We can use the value-centred nature of Luddism to judge what is most essential. In ensuring that all of these essential needs are met, we can consider our options. Some solutions will involve a great deal of complex technology; some will not. The solutions can be evaluated based on their outcomes and the resources they require, rather than how much shiny tech and new economic value they produce. A great exercise in practical Luddism is thinking about the solutions we currently employ around these issues and creatively whittling down the technology used in them or imagining what would happen if we destroyed that technology—a practice known as methodological Luddism (Lu s Garcia et al. 2018, Winner 1978).

The thing about these core issues is that they are communal. They aren’t things we can change on an individual basis—your plumbing, grocery store, and workplace are mostly out of your control. I can’t reject all mechanized transit if I live far from the only job I could find. I can’t even readily reject having a cellphone while it’s the only way that I can communicate with my family. We come back to the regular refrain: we live in a society. So, any practical change in our use of technology must be a large group effort.

Not all of these groups have to be as big as a society (whatever that is). There are some changes which can be made within family, friend, community, and work groups to rely on different technologies. We could think, for instance, about entertainment choices for a group of friends. They might haphazardly

each watch a Netflix series on their own over the course of several weeks, making use of the technology of on-demand streaming. Or, they could schedule a time when they can all get together every week and watch it together, making use of the technology of a calendar to reduce reliance on streaming. This is a small example, and doesn't by any means abolish the massive environmental drag that is Net ix, but we could take this as a starting point. Maybe we move forward by sharing television shows between community centres using peer-to-peer protocols over local internets and reducing our expectation that we be able to watch what we want when we want to at home.

Isolation

Now we are all alone. We can't bring the block together for a movie night (unless our building looks on to a great big white wall). How are we supposed to fill our core needs in a local & communal way while taking their resource draw into consideration? When isolation began, I felt suddenly like all of my ideas needed to be re-evaluated. Devices and the internet were going to keep people connected, reduce tolls on mental & physical health, and allow some to work. How could I continue to be critical of our tech-focused lives?

After dwelling in isolation for so many weeks, I feel more confirmed than ever in the Luddite approach. We clearly need to be tackling essential problems using solutions which we can, which are low resource and/or high reward for human life and all life on this planet. We've seen very clearly the important of having very good medical and public health apparatuses, for instance. This includes advanced material tech like ventilators and space in hospitals, low tech like soap and handwashing practices, and a lot of human power and associated organizational technologies and professional knowledge in nurses, doctors, and epidemiologists. A coordinated public health response involving widespread testing and contact tracing, as in South Korea, undoubtedly would have prevented thousands of deaths in Canada and maybe even isolation orders.¹

Our most essential services seem to be easier to identify, even when they are missing. We need connection, supplies, and care. We feel keenly the absence of faith services, the hug of a friend, the bustle of a park. We feel confusion and outrage at the continued presence of workers building an illegal pipeline or working on condo building.

I'm also confused by the necessity of relying on internet-based communication. I wanted, before, to step away from the internet, to be more local. Now I don't talk to anyone in person. I crave the cadence of in-person chatting. It would be worse, no doubt, to be without Zoom. But we are obligated to it. Ivan Illich writes about creating tools of conviviality—spaces where our ability to choose to create together things which improve our intertwined lives (Illich 1975). It is clear that in isolation our ability to choose is more limited than before. But we also know that this is temporary, even if it lasts for a long time. We need to think of the strategic response moving forward. People's increased reliance on personal communication devices may pose an issue to convincing more of them to move away from the ubiquity of this technology.

¹ The Korean response has also involved a great deal of mass surveillance, which has its own problems.

Many Luddite solutions to our problems are still available to us—they just still require societal buy-in and long-term development. Devices can be made to be repairable, with fewer features, reducing the demand for new metals while maintaining the essential communication benefits of a smartphone. Cities can still be made walkable and bikeable with widespread and accessible intra- and inter-city public transit. The internet can still be transformed into something which is locally connected, where people maintain local storage and rely less on streaming. It will just take time and concerted effort on the part of individuals, groups, and especially the makers of technology.

Education

Educators have been resisting technology in many ways for a long time, from early issues with adopting computers through Ontario teachers' strike demands for no required e-learning (Bryson & De Castell 1998, Halves 2014). Stephen Lecce, the Ontario Minister of Education, said that "technological fluency is a foundational skill that also needs to be harnessed in today's disruptive economy and the trajectory of where the market is going" (Mauracher 2020). Clearly, the Ontario government, like many others, views education as basic training for the workforce and believes that the essential issue that schools must address is how to support capitalism, rather than how to improve society in a more fulsome way. Ontario teachers have resisted this requirement for several reasons. Students do not have uniform access to computers and internet. E-learning provides a poor forum for connection with students. There is also evidence that dropout rates in online courses are as high as 40%, drawing deeply into question their effectiveness as a learning tool at all.

In this crisis, these core issues haven't changed all that much—we're just also in a crisis. Students don't have access to the internet, plus they and their family may have lost employment, gotten sick, or are worried about getting sick.² Hundreds of thousands of people have already died worldwide. Many more are grieving. This Luddite approach is to identify the essential issues within this mess in line with core values and evaluate ways to address them with resources and freedoms in mind.

Core issues might include connection, support, and avoiding punishment from not meeting requirements. Perhaps continuing to meet curriculum or the planned syllabus is not a core issue. If we use a little methodological Luddism, we can imagine what parts of courses we can do without right now. Why not do this exercise with students? What do students need, and how can those needs be met with the least resource draw possible? Maybe the result will be something you all could use. Perhaps your school boards that running online classes, but maybe that doesn't require online lectures. We could try to go low-tech. Think peer-to-peer phone conversations, mail, asking for fewer assignments, going pass/fail. Let's seek what is engaging or distracting from the crises.

Most of all, responding to core issues means helping students to make sense of the change in their world and of the injustice that was already here and has manifested more intensely. The most Luddite

² We may also think about this in the terms of critical place-based pedagogy (Gruenewald/Greenwood 2003). Many of our places now are anxious, in crisis, isolated, poorer, sick, and getting sicker. How can we help students and ourselves to understand these places and to be of help to themselves and others within them? We can use a critical lens on the systems of power that have structured our world and the specific places that we are in and act locally to in response.

pedagogy I can think of is one which advocates for Luddite approaches to the problems we face. Ask, with your students, what is essential? What can we go without? How can we get there together?

All together now

If we seek to build a long-lasting, livable world for all, we must be less resource-intensive, more community oriented, and drastically upend the power structures of our world. The Luddite approach discussed here is one which seeks to highlight how dependent we are on one another and on our planet, to go more slowly, and to do away with complex technology as the necessary answer to all of our problems. As educators and as individuals, the best way that we can support this is to facilitate education and community in service of local connection, community resilience, understanding the problems we face, and demanding change collectively of those with the power to enact it.

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Collegial Conversations at a Time of COVID-19

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Abstract. During the COVID-19 pandemic in 2020, citizens and social institutions have been called into action. Questions of the future of school and an appropriate educational response to the pandemic have been widely discussed and debated. As scholars of science education, subjects particularly relevant to educating about the virus and its transmission, we discuss the roles and responsibilities of science education during pandemic. The format of this paper is a dialogue. We discuss theoretical positions related to science education and the pandemic, inequalities and injustices, recent anti-Black racism protests, and concrete pedagogical responses. As our discussion progressed, we increasingly recognize teachers and students as crucial agents in developing community-grounded, critical place-based, educational responses, recognising and addressing injustices related to differential global and local realities experienced during the pandemic.

Keywords: Dialogue • Science Education • Black Lives Matter • Racism

Steve Alsop and Darren Hoeg are colleagues in the Faculty of Education, York University. They share academic backgrounds in science education. Steve is a longstanding faculty member at York and Darren is relatively new, having previously worked at the University of Alberta. They both live and work in Toronto, Canada. The following exchange took place over the period of the first phase of the coronavirus lockdown (in May and June 2020). The choice of format sought recognition of the importance of collegiality and discussion at a time when working remotely from home online was the only option available and affecting collegial exchanges. Our conversation was a way of getting to know each other, in addition to discussing how we might contribute to an educational response to COVID-19. Our conversation was seen as a starting place to begin to grapple with the disequilibrium and creative potentials arising from the pandemic. Our conversation, or as Paulo Freire termed it, 'dialogue', is a dialogical form in which knowledge is co-created by those in conversation, instead of imposed on an individual or group, as is often the case with research methods, and school curriculum. We see this format as a model, and starting point, to foster discussions among educational communities that must develop educational experiences in a time of COVID-19. It is through discussions between students and teachers and community stakeholders that relevant forms of education for COVID-19 that enable social and ecological justice might be developed.

Steve (Thursday, May 14th): Hi Darren, I hope all is well. Thank you for the suggestion of writing this article in the form of conversation. At a time of lockdown and professional isolation it seems such an appropriate approach to explore. Dialogic teaching is talked about so often in education. I hope that this dialogue might bring others into educational conversations at a stage of so much uncertainty and anxiety. Dialogue is a special, social process of re-imagining, of trying out new possibilities, sharing doubts and uncertainties, and changing ourselves with others. It has a foundational role in education reforms. I am immediately reminded of Freire's and Shor's "dialogues on transforming education"¹.

¹ Freire, P., & Shor, I. (1987). *A pedagogy for liberation: Dialogues on transforming education*. London: Macmillian Education. (p.3)

Having said this, I want to start by saying how difficult it is to think and write in the midst of pandemic, let alone start a dialogue about education that others might read. Clarity, it is often said, needs the perspectives and privileges of time. My life - all our lives - have traumatically changed with structures and rhythms shattered and makeshift replacements now taking hold. Our professional “new normal” is that the university has been closed for the past 3 months with no physical access. I have been teaching and meeting students on Zoom™, sharing my feelings and thoughts, talking about the pandemic, listening to students and their families and friends’ experiences; reassuring them that the term will not be lost, and providing flexibility to get things finalised. I have been trying to ‘make it work’ with sensitivity and compassion. It is strange how everything has changed and yet these educational pieces still somehow remain. Is this a legitimate education response to COVID-19? Like all of us, I guess, I am trying to make sense of it all. As a professor, a science teacher, I ask myself, what I can say that is helpful at this time? I am critically self-aware of the need to reach out, to actively make room for others to be heard - to listen carefully, especially to those who are being personally and professionally affected by the virus much more severely than I am.

Carusi and colleagues reflect on “Doing Academia in COVID-19 Times”². Beyond medicine, epidemiology, virology, nursing and other academic pursuits with genuine frontline expertise, they explore what social sciences and humanities might offer this crisis. They are critical of the motives of hurried scholarship seeking to define and claim (academic) credit for the crisis. There is certainly an increasing abundance of COVID special issues of journals (including this one, of course) and books. In these, there are ownership moves of simultaneously defining reality and making it accountable to such definitions. Carusi and colleagues caution against quick and unnecessarily hurried judgements in framing, for example, the COVID Generation, COVID Society, COVID Capitalism or COVID Education. In place of academic labels and quick policy fixes, they conclude, “we need questions that can actually help us think, that enable us to see the novelty of the present [...] so we can find our feet again” [last para.]. So, perhaps this is one starting point for these collegial conversations: what are some important science education questions about COVID-19? As academic science educators with particular expertise, what questions do ‘we’ need, and what questions might ‘we’ helpfully share with others?

Darren (Saturday, May 16th): Steve, I’m writing this response on a day Ontario has announced 390 new COVID-19 cases, from roughly half of the tests averaged over the previous 10 days. This represents a significant increase in confirmed COVID-19 infections, just as isolation restrictions have weakened, causing speculation we may be amidst a ‘second peak’. This is an example of the uncertainty of the times, which make prescribed curriculum fixes seem ill-suited. I agree with you Steve, that in this time of instability, it seems more appropriate to start with dialogue and questions about what has and is occurring, rather than reactionary social and educational solutions. Since I’ve been thinking about connections between social oppressions with the pandemic, Freirean-esque dialogue that attempts to understand the local conditions of oppression seems to be a good method to base our conversation on. Although an urgent pragmatism fuels the call for solutions, the very nature of a solution assumes we know what the problem is and are ready to address it. Since we are not at this point, I think there needs to be school-based inquiry into what has actually occurred and how it is affecting communities, before solutions are

² Carusi, T., Paolantonio, M., Hodgson, N. & Ramaekers, S. (2020). *Doing academia in “COVID-19 Times”*. Retrieved from: <https://drnaomihodgson.wordpress.com/2020/04/10/doing-academia-in-covid-19-times/>

attempted. At the same time, the pressing need to leverage education as part of a pandemic response, now, limits the time available for necessary grass-roots inquiry.

As I write this, I realize how working from home is a privilege that many workers do not share, as their jobs have been effectively wiped away by the pandemic. Just who is able to work from home, how effectively, and what are the consequences? The corollary to this question related to school is, who is able to learn from home, and how well? These immediate questions set off a cascade of other related questions in my mind, in no particular order, such as: Who can practise social distancing? What's the cost to stay safe? Who can access the internet? Who can access health care? Who has access to ventilators? Who gets emergency response benefit payments? How are lockdowns enforced, and who is subject to enforcement? Who gets blamed? How does lockdown differentially affect genders? These questions focus attention on inequities that already exist in society, which the pandemic has re-illuminated and appears to have exacerbated³. For example, despite the perceived success and celebration of work-from-home practices (a measure of which may be the sudden ubiquity of the texting acronym WFH) many workers have lost their jobs as a result of the pandemic or have been forced into essential work with increased risks to personal health. Citizens who have not been able to work from home are disproportionately females and those of low socio-economic status⁴. The ability to socially-distance is another practice closely associated with socioeconomic status and privilege³. In addition, the added cost of staying safe is beyond the economic capabilities of many households, already strapped from lowered income during the pandemic⁵. As we "zoom"-in on school, the question of who has access to the internet, and how students learn from home becomes prescient. Although we may not be able to answer these questions yet, one in ten Canadians do not have access to the internet⁶, suggesting many students are unable to access this learning resource made essential during the pandemic. Considering the inherent justice issues bound up within considerations of (science) education during COVID-19, I suppose I start to wonder what can and should be the role of science education, in addressing these social inequities. And what are our roles, as privileged academics who may not experience the pandemic the way students and teachers have? While the responsibility to educate students about the science involved in pandemics and viruses seems fairly straightforward, the ethical and moral implications of the pandemic appear to be fertile and necessary terrain that school science may need to take stance on. What are your thoughts, Steve?

Steve (Monday, May 25th): Thank you, Darren. You leave me reflecting on how we can care and look after each other if we are ignorant of the very conditions that continue to separate us. As [science] educators, how can we respond to the pandemic without fully understanding the extent and nature of its discriminatory impacts? Yes, we are all vulnerable to COVID-19, and representations such as the now infamous 'bell curve' and 'R-value' bring us together jurisdictionally and nationally. This is such an important way of understanding the virus, but this virus affects different groups in very different ways. Much recent evidence suggests that COVID-19 discriminates in terms of antecedent health and medical

³ Lindeman, T. (2020). Why are so many people getting sick and dying in Montreal from COVID-19. *The Guardian*. Retrieved on May 20, 2020 from <https://www.theguardian.com/world/2020/may/13/coronavirus-montreal-canada-hit-hard>

⁴ Drimonis, T. (2020). Quebec has abandoned front-line health care workers. Retrieved May 20, 2020 from <https://cultmtl.com/2020/04/quebec-has-abandoned-frontline-healthcare-workers/>

⁵ Brown, D. (2020). Stockpiling a week's supply of food 'not an option' for many as Toronto sees increase in food bank use. Retrieved on May 20, 2020 from

<https://www.cbc.ca/news/canada/toronto/stockpiling-food-coronavirus-1.5481434>

⁶ Statistics Canada (2019). Canadian Internet Use Survey. Retrieved on May 20, 2020 from: <https://www150.statcan.gc.ca/n1/daily-quotidien/191029/dq191029a-eng.htm>

condition (including age and genetics) and also in terms of pre-existing economic, social, cultural, material and geographic conditions and inequalities. Rebecca Solnit points out that “Coronavirus does discriminate, because that’s what humans do”⁷. She invites me to think of science and technology education as joining with others to take better care of each other. This necessitates simultaneously taking a step-back, recognising not only our shared humanity (our compassions, hopes, fears and vulnerabilities; our shared communities and our shared Planet), but also differences - the privileges, injustices and discriminations that continue to separate us.

As I listen to daily news reports on COVID-19, they remind me of the very public and deeply political nature of this virus. There is continued reference to “scientific expertise” and the need to follow “the” scientific advice. Scientific expertise in the form of medical and nursing practices, better epidemiological and biochemical models, tests and vaccinations are central to coming to grips with this large positively stranded RNA virus (SAR-CoV-2). I am, however, acutely cognisant of relationships between science, politics and society that are so much more complex and nuanced than government briefings want me to believe. A long time ago, I recall reading an article by Anne Fausto-Sterling⁸ on how best to teach embryology. Fausto-Sterling finds herself drawn to endless hybrids and networks in which biology, culture and societies come together, knot and entwine. Once you start to notice these hybrids, she reflects, they seem to be everywhere, to the extent that it is difficult to get them to disappear. Perhaps this is now an obvious point: in the case of COVID-19, the virus, politics and societies are inseparable, contiguous and co-productive. This is broadly the coproduction thesis⁹ that so many STS and science and technology education researchers write about.

When I watch the daily news reports, I am continually thinking about these hybrids, as well as the power accrued from the modernist move of denying them. When politicians claim that they are following “the” science, I cry out what science, when, where, how, why and with whom? And for what reasons and goals? Here I am acutely sensitive to forms of politics-without-politics, types of political decision-making that appear to be not making political decisions. This type of self-referential logic is so dangerous, because it closes down democratic participation. It makes politics seem a-political, thereby masking political discussions, choices and alternative possibilities. Seeing hybrids are teaching invitations to reflect on associated relations of sciences, power, privileges and discriminations.

I am concerned that science teaching about SAR-CoV-2 will follow engrained traditions and stubbornly focus on the ‘technical’ natures of this virus and miss all these political, economic, material, societal, and ethical pieces. I really do not want COVID-19 science education to resemble government briefings. Indeed, I want the opposite, for it to offer openings to challenge these briefings, and thereby allow people to become more politically and ethically informed and engaged. This type of critical analysis and dissent are essential for democracy, and active democratic participation.

Your comments also invite me to also think about how this pandemic is altering conditions of education (as well as the reverse: how is education is implicated in conditions of the pandemic). Your point is that the seemingly convenient and self-evidently desirable decision to move education on-line (as a response to COVID-19) needs much more careful and critical attention. Certainly, in my experiences, online learning is offered as “a solution”, but the solution to what, where and for whom, is under-

⁷ Solnit, R. (2010). Coronavirus does discriminate, because that’s what humans do. *The Guardian*, Friday 17th April, 07.00 BST. Available on line: <https://www.theguardian.com/commentisfree/2020/apr/17/coronavirus-discriminate-humans-racism-sexism-inequality>

⁸ Fausto-Sterling, A. (2003). Science matters, culture matters. *Perspectives in Biology and Medicine*, 46(1), 109-124.

⁹ Jasanoff, S. (2004). *States of knowledge: The co-production of science and social order*. Routledge Taylor & Francis Group.

discussed. It is an answer without questions. Perhaps some basic questions are: why is online learning so seemingly desirable? How ought it be judged? What can it offer at this moment? Don't get me wrong, I can obviously see many medical and educational advantages. But I also want to understand what it cannot offer, how it empowers and disempowers. As educators, for example, I think we need to keep a very close eye on powerful and high influential tech-companies with particular visions of the future combined with economic market dominance. I want to know how much of the recent government education bailout end up in these already excessively wealthy corporations, as well as the increasing influences that these organisations have in shaping public education. I encourage critical reflections on ways that online learning is potentially furthering and exacerbating social inequalities. Without these types of critical discussions, there is an ever-present danger of teaching the virus without the social conditions of the virus. It is another modernist move of separating science, technology and progress from societies and politics. This coronavirus allows us to see injustices in educational practices, which have overtime become faded and silenced. We can reach out and join with others for change. It provides bases for potentially transformative online educations. However, if we overlook these injustices and contradictions (seeing 'the' solution and 'the' future as online learning) we are ill-positioned to appropriately respond. So, concluding with the spirit of asking questions, I wonder: where, how and in what ways is this pandemic educational? What inequalities in our educational practices are the virus rendering more visible? How might we join with others, recognising these inequalities, and act to shape more healthy, equitable and environmentally sustainable futures?

Darren (Thursday, May 28th): Thanks Steve for your thoughtful response, and, like you, I'm wondering more and more what I can and indeed *should* do, as a science education scholar. We've asked a lot of questions; to advance our discussion, I'm going to move from the ideological (what might be) into the realm of the material (what can be/what is), in terms of my thoughts on science education's response to COVID-19.

The mixed messages surrounding the use of masks to prevent the spread of COVID-19 must be one of the most concerning examples in Canada of the hybrids of science and politics you mention. As background to this issue, initially, Canada's Prime Minister, Justin Trudeau, on the advice of the Public Health Agency of Canada (PHAC), declared that there was little scientific evidence that surgical masks prevented the spread of COVID-19. This advice contradicted that given in other countries, such as those in East Asia, where the use of such masks is more widespread¹⁰. Over the following weeks, the political-scientific discourse in Canada surrounding masks slowly changed, acknowledging masks may have the benefit of containing infection to the wearer of a mask. The most recent suggestions from the PHAC is that everyone should wear a mask in public if possible and that even cloth masks, such as a scarf, may have some beneficial effects. These changes in public discourse correlate with increased supplies of masks in Canada, causing some to speculate whether initial denials of the efficacy of masks was based on economic realities, rather than scientific ones. If this is true, these changing beliefs are based on certain ontological assumptions – that the population represents 'a problem', that the perceptions and practices of the population need to be controlled, and that this control might be achieved through forms of communication, texts, and/or discourse. The use of science and official knowledge to support particular political discourses meant to shape public perception and practice appears to be a form of what Foucault

¹⁰ Xu, X. (2020). Cultures clash over wearing masks amid virus. The Globe and Mail. Retrieved May 25, 2020 from <https://www.theglobeandmail.com/canada/british-columbia/articlecultures-clash-over-wearing-masks-amid-virus/>

has termed biopolitics¹¹. What biopolitics generally means in Foucault's¹² work is a type of politics that "deals...with the population as political problem, as a problem that is at once scientific and political, as a biological problem, as power's problem" (245). Larry Bencze and I have written about biopolitics in science education elsewhere, making the case for the need to examine biopolitical assumptions underlying STSE issues, in order to address these in school science. The controversy of masks would be excellent content through which to learn about nature of science, socio-scientific issues, and viral epidemiology, as well as student-activism related to this issue. Many ideas, from sanitary practices to treatment options, have been dismissed during the pandemic by the statement "There is currently no scientific data to support this" (i.e. Ibuprofen makes symptoms of COVID-19 infection worse), which reproduces the misconception that 'solutions' are always preceded by basic science. These would make excellent case studies to discuss with students' notions such as validity of science knowledge, co-production of knowledge, and other ways of knowing. Today, in any public space in Toronto, you still see many people without masks, which causes me to wonder who has access to these devices, how, and why? These are important topics communities of learners might inquire about.

This brings me in a round-about fashion to the topic of online learning. Like you, Steve, our colleagues, and millions of workers around the globe, I have had the privilege of working from home, through various online platforms. You and I have discussed this, how, although we are working, we feel displaced from work, and the mental and emotional adaptations required to work effectively from home during the pandemic take a toll, while acknowledging we are among the fortunate. On the one hand, I feel we must celebrate our technological capacity to allow work and school to continue while social institutions have closed their doors, yet I fear in the mad rush to accommodate people staying home, there needs to be more critical attention to the discourses online work advances, and what might be lost. I have attended (virtually) several workshops that demonstrate how communities of learners and social interaction might be enabled through online instruction, yet I have difficulty seeing how affective and socio-political orientations, which have been shown to be important for commitment to activism, might be fostered¹³. Perhaps I was born in the 'wrong' era, and therefore somehow see the online experience as artificial, despite being told by workshop moderators that 'digital natives' who make up the majority of our students, perceive online environments differently. I tell myself to delay judgment until after I have more experience and expertise teaching online, yet I wonder how my preconceptions might already work to make the online classroom the inferior counterpart to face-to-face classrooms. I think the theme of access and equity that can be seen threading throughout our discussion is nowhere more relevant than in the case of online learning. Access to technology is the most apparent consideration, but as Karen Strassler¹⁴ writes, the environments of online VS physical classrooms themselves have inherently different characteristics important to equity. At least the classroom is an environment where students have equal space to work, where they meet as apparent equals, they sit in the same chairs. In my online experiences during the pandemic, I spend an inordinate amount of time observing and evaluating the work-from-home environments of those I've interacted with. Who has office space? Is there a window? What can be seen through the window? What other people or things are in the background? The loss of assumptions of equity are quickly lost in such encounters. While this may do the important work of making inequity visible,

¹¹ Hardt, M., & Negri, A. (2000). *Empire*. Cambridge, MA: Harvard University Press.

¹² Foucault, M. (2003) *Society must be defended: Lectures at the Collège de France 1975–1976* (D. Macey, Trans.). New York: Picador.

¹³ Watts, R., Williams, N. C., & Jagers, R. (2003). Sociopolitical development. *American Journal of Community Psychology*, 31, 185–194. doi:10.1023/A:1023091024140.

¹⁴ Strassler, K. (2020). What we lose when we go from the classroom to Zoom. *The New York Times*. Retrieved on May 25, 2020 from <https://www.nytimes.com/2020/05/04/sunday-review/zoom-college-classroom.html>

it seems to do so without the consent of students, so it potentially both reveals and magnifies inequity. I believe, therefore, before we celebrate online learning as a new norm, critical inquiry into the discourses reproduced and associated equity issues must be undertaken.

Steve (Tuesday, June 2nd): Thank you, Darren. In terms of the “realm of the material”, I am reminded of the increasing number of creative COVID-19 science education resources that are widely and freely available. The San Francisco Exploratorium, for example, has a COVID-19 Science Learning Toolbox, with “science snacks” that include templates for making model viruses out of paper, string and cotton wool (illustrating the identical proteins that make up the capsid); a soap film model demonstrating how virus membranes behave and can be disrupted through soap; and a string and pony-bead necklace to illustrate the genetic sequence of coronavirus RNA (rather than DNA) with an accompanying Codon table¹⁵. These ‘hands-on’ activities are really good at teaching about virology, focusing on the nature of virus. They warrant extending to include discussions of ethics and politics, including the biopolitics that you highlight.

As an example, you highlight facemasks and get me thinking about possible teaching approaches. What are some different ways of better understanding what has now become one of the world’s most desirable commodities? There are a number of online templates in which students build face masks. There is, of course, a proliferation of research into the efficacy of facemasks (with respect to transmission characteristics and different materials). I like the idea of thinking about the mask as a “source of controversy”. I think that studies of science in the media are so important. Students might follow the mask as a controversy in newspapers and social media discussing not only what makes the mask a useful response to the pandemic, but also when and how is its controversial nature resolved and unresolved? A study to unmask the masks, if you like. Perhaps this could usefully connect with broader discussions of controversies and the politics of doubt. I used to read Oreskes and Conway’s “Merchants of Doubt” with my education students, which picks up this point.

Scientific research on COVID-19 is ongoing and emerging, and it is quite likely that some (perhaps most) will turn out to be wrong. Researchers are being propelled to sort things out with desires of/for policy answers, but the speed of research and policy are often very different. I’m sure that scientific research can be frustratingly glacial. This is part of the nature of science that you mention. As science educators, this places us with responsibilities to represent science as emerging, as tentative, as slow, as political, but in a way that doesn’t undermine its expertise and credibility. I recognise that this is not always an easy balance.

I teach a graduate class on science, technology and society, which includes an assignment based on Joseph Dumit’s provocation of “writing the implosion” by “teaching the world one thing at a time”¹⁶. The students seem to really enjoy picking and unpacking an object (a technology) and exploring what it means to different groups and how it is situated in the world and the world is situated in it. They start with common everyday understandings and then through research and discussion, they slowly awaken to other stories and accounts. What is at first a comfortable, invisible, throwaway thing, becomes an increasingly complex and problematic hybridised entity. Then, perhaps most importantly, following Dumit’s 4-twist method, the students slowly turn the implosion in on themselves, questioning their assumptions,

¹⁵ Exploratorium (2020). Learning Toolbox: COVID-19 Science. Available at: <https://www.exploratorium.edu/learn>

¹⁶ Dumit, J. (2014). WRITING THE IMPLOSION: Teaching the World One Thing at a Time, *Cultural Anthropology*, 29(2), 344-362. Available online: <https://journal.culanth.org/index.php/ca/article/view/ca29.2.09>

knowledge, and ways of making sense of the world. This critical consciousness-raising exercise enables students and professors to recognise ways they, and powerful others, are implicated in reproducing worlds. They can now explore whether this needs changing and ways that they might bring about changes, joining us in coalitions acting for better, more just and environmentally sustainable possibilities.

With this approach, I like to imagine that I could teach a whole course on the face mask exploring various dimensions with students, including - drawing from Dumit again - the masks': "labour dimensions" (Where and who was involved in its production?); "professional dimensions" (What types of professionals are involved? What types of knowledge are involved in its development?); "material dimensions" (What is it made of and where do these materials come from?); "technological dimensions" (What types of machines were involved in its production?); "context dimensions" (What kinds of activities and ways of life can it support and not?); "economic dimensions" (How is it marketed and branded? What are associated profits and how are these distributed?). You bring my attention to "political dimensions" and the ways in which objects (such as face masks) can [deviously] shift our consent to dominate orders. I like to add environmental dimensions (what environmental impact does the mask have from construction to disposal). These are very pressing questions now and in the future.

Just to pick up on the labour dimensions. Even a cursory internet search reveals ways in which masks are deeply implicated in promulgating world injustices and precious labour practices. Prison labour is being used to make face masks in the US and Hong Kong. Many masks are produced in sweatshop conditions in which workers are paid sub-minimal wages on short time precarious contracts, with restricted working conditions that are more vulnerable to the coronavirus. For example, Sam Dean, staff writer for The San Diego Union-Tribune, writes about Santiago, a worker in a downtown factory in LA who was scared to give his full name, and had just got paid for the first week of making masks: "\$230, in cash, for 50 hours of work. That's \$4.60 an hour, for essential work"¹⁷. We need to ask: why and how can this be happening? Who is allowing it to take place? How can it be stopped?

This is just one example. The general point is that a science education response to COVID-19 should offer opportunities for students to understand ways in which the virus (and surrounding technologies) are embedded in world injustices, including patriarchal, colonial, class and capitalist systems of oppression. Perhaps in this manner, turning to Dumit once more; "we confront the histories and the intolerable not just in objects but in ourselves, in our identities as partial, in our senses, our worries, and our common sense". Perhaps this will awaken activists, those who join with others and mobilise for change. Making the seemingly mundane (or banal) intolerable is a really good way to raise critical consciousness.

I am also mindful of mindsets that reduce everything to the corruptions of systems of oppression and thereby perpetually rehearses worlds in death grips of prejudice, greed and market forces. It is equally important to remember that face masks can be conceived as acts of altruism - wearing them is to protect others (in addition to protecting ourselves). This pandemic is full of acts in which people have sacrificed personal health and financial security (choosing well-being over money) even before government policies. Face masks have been distributed freely to communities which are unable to afford them, and face masks are being produced and distributed by volunteers. Knowing and understanding this is equally important. This pandemic is about caring with each other, and to miss this point is a mistake. Yes, as a privileged White, cis-gendered male, science educator, I need to continue to confront the intolerable in my

¹⁷ Dean, S. (2020). The sweatshops are still open. Now they make masks. *The San Diego Union-Tribune*. April 21, 2020, 7:15am.

perspectives and actions, but in so doing I should not abandon my capacities for helpful acts of generosity and kindness and playing a role in change.

I am continuously inspired by care-givers, parents, elder siblings, science teachers and students now all working in unfamiliar and unforgiving online contexts and putting in all those extra hours and efforts in response to extraordinary times, which I am sure can seem intolerable. The general point is that this pandemic has many stories to tell about science education in the “realm of the material” – stories about who we are, what is, and what can/might be possible in the future. What we need to let go of? What do we need to cling to more tightly? Being an educator is deciding which stories to focus on and how to develop these to release the scientific imagination.

Darren (Friday, June 5th): I love your idea, Steve, of face masks as the theme to explore various aspects of the pandemic, from the biological, to the socio-scientific. This aligns with the suggestions of many science educators as to how Science, Technology, Society and Environments (STSE) might be taught in school science¹⁸. Like you, I have found it heartwarming to see acts based on kindness, generosity, and altruism as life has been altered to ‘flatten the curve’. At times, I’ve felt a sense of community I seldom experience, as I am instead critically aware of the radical individualism that seems to permeate all levels of society. We have heard stories of some corporations re-tooling production lines to produce and supply much needed medical supplies and PPE (personal protection equipment) - another acronym that has become part of the public discourse due to the pandemic – muddying the critical view of capitalism and ‘the corporation’ as inexorable evils, akin to a form of social cancer, or a virus. From my pedestal as a university professor with a secure job and salary, safe place to live, and ability to work from home, it is easy to have a rosy view, as the pandemic has brought out acts of social responsibility and community engagement.

As I sit here writing this in my high-rise condo, in downtown Toronto, I realize this image is an apt metaphor of privilege, which allows me to be separate from the ugliness of ‘real’ life below on the streets. I’m reminded that our privileged experience of life during COVID-19 is not shared by everyone, or perhaps even the majority, and there has been a darker and more sinister reality to the way many people have experienced the pandemic. In fact, there is a protest happening today on the street below, 18 floors down. I hear cowbells and shouts and chants of “I can’t breathe”, referring to the words of George Floyd, captured on video, as his life was stamped out of him as he was asphyxiated by the foot of a Minneapolis Police officer. This incident, and the resulting worldwide re-ignition of ‘Black Lives Matter’ protests, have been packaged by the media as a new commodity, aside from the pandemic, but they are in fact inseparable, as they both reveal the systemic racism in society that sours our celebration of community goodwill and communion. It is a fact that COVID-19 has impacted people of colour and other marginalized communities more seriously than advantaged communities, as they make up the bulk of ‘essential service workers’ and may not have the financial capacity to isolate and physically distance¹⁹. It is not a matter of coincidence that those most likely to participate in “Black Lives Matter” protests, the close confines of which exposes them to high risk of contracting COVID-19, are part of marginalized communities that are also more at risk for acquiring COVID-19 infection in their daily lives.

¹⁸ Pedretti, E. & Nazir, J. (2011). Currents in STSE education: Mapping a complex field, 40 years on. *Science Education*, 601-626.

¹⁹ Winsa, P. (2020). *Which workers are being hit hardest by the COVID-19 lockdown? These 6 graphics paint a stark picture of Canadian inequality*. The Star. Retrieve on June 5, 2020 from <https://www.thestar.com/news/canada/2020/05/28/which-workers-are-being-hit-hardest-by-the-covid-19-lockdown-these-6-graphics-paint-a-stark-picture-of-canadian-inequality.html>

I've thought awhile about how to respond to the horrific Black racism and murder that has occurred in the US and Canada recently. As a citizen, I try to understand. As a science educator, I want to do something. I want to educate my students, future teachers, about racism in schools. School is one of the social institutions that perpetuates racism and privilege. The curriculum in Canadian schools has been identified through research as Eurocentric (White), privileging already advantaged students, and marginalizing those the curriculum 'does not have in mind' in its design²⁰. As educators, we need to be aware of the hidden biases in school curriculum, our own privilege and 'blind spots', and the way we may reproduce privilege and oppression in our practice. We can't accept narrow reproductions of curriculum that perpetuate racism in society so that some students can attain their 'allotted' status in society when other students fall by the wayside, and whose very livelihoods and lives might be at stake. Common rationalizations such as the need to prepare students (which students) for exams and university seem weak considering the social cost of this education to groups of students that are not represented in or by dominant curriculum teaching and learning. We must find ways to confront the racial biases in school and find ways to teach and evaluate students based on broader conceptions of education that care for and nurture human life and potential, rather than a narrow set of skills and knowledge that perpetuate racism.

So, how do we do this? How do we make racism a topic in school science? Once again, 'the pandemic', despite its terrible cost, seems to present an opportunity. As I write this, I imagine students' stories of the pandemic, science and oppression informing science lessons. What do students know about the pandemic? Is science knowledge related to COVID-19 racialized? There exists in society assumptions that, because knowledge is available freely on the internet and television, everyone has equal access to it. In fact, we know this is not the case, and access to knowledge is dependant on a number of identity markers, and a function of privilege. Who are the students in the privileged position to know the science of viral transmission, and who are not? Additionally, schools in marginalized neighborhoods may have local issues related to science and society to address, such as the best way to make and/or sterilize home-made masks, how to keep underfunded public school environments clean to prevent viral spread, as well as public awareness campaigns around these issues. In the spirit of community support and good will we have discussed in our conversation, more advantaged schools might work in partnership with less advantaged ones, sharing stories, knowledge and resources, in a community effort to both eradicate the spread of COVID-19, but as well to set up the conversations and relationships necessary to address racism and oppressions as we strive for a more just society. If the ultimate goal is to end systemic racisms and oppressions, these are the types of social interactions needed among citizens. Engaging students in these in school can foster a sense of agency needed to engage in citizen participation in social issues as an adult²¹.

Steve, since racism is such an essential topic for schools, but made more visceral recently due to the high-profile deaths of George Floyd and ensuing protests during the pandemic, I welcome your thoughts. I also wonder if we might conclude this discussion by talking about the environmental implications of the pandemic, and how these are relevant to school science and activism.

²⁰ James, C. (2019). We Rise Together. Peel District School Board. Retrieved on June 5, 2020 from <https://www.peelschools.org/aboutus/equity/Documents/We%20Rise%20Together%20report%20-%20Carl%20E%20James%20June%202019.pdf>

²¹ Bencze, J. L. (2017). Science and technology education promoting wellbeing for individuals, societies and environments. Dordrecht, Netherlands: Springer International Publishing

Steve (Wednesday, June 17th): Hey Darren, you raise such fundamental questions and leave me wondering how I might appropriately respond in this somewhat constrained letter format. I notice that our letters are getting steadily longer and as I start a reply, I sense this is going to be a protracted response.

I am heartened by increasing attention given to STSE and various other approaches to science education that focus on socio-scientific issues and controversies. I suspect that our preceding curricula discussions align with some of these and depart from others. In my experiences, much science education practice and research - including approaches to STSE education – still downplay the histories, politics and economics of issues and controversies. The comprehensive review that you highlight brings attention to the lack of political analysis in STSE practices, which is taken up further in really thoughtful ways by Lyn Carter²². This absence is, in part, a result of a legacy of thinking about science education with particular ‘liberal’ expressions of citizenship - the idea that science curricula should focus on scientific knowledges that future citizens need to know to make decisions to exercise their individual liberties most effectively and successfully. This is an important part of the picture; however, as critical commentators point-out, such notions of citizenship are restrictively homogenised, offering limited attention to gender, sexuality, race, colonialism, poverty, class and disability. Marginalised, disempowered groups continue to be excluded from the discourses and associated agencies of ‘science citizenship’ (as this pandemic demonstrates because of their subordinated position in society), shaped by these and many other intersecting and accumulating factors including age, qualification, geography and nationality. The point is that we need to place inequalities, injustices, power and privilege at the centre of science education reforms.

I still believe that individualised, technical, homogenised approaches to scientific literacy and civic engagement are by themselves unlikely to bring about necessary far-reaching social and ecological reforms. There is so much to celebrate in projects of community service and civic awareness. However, activism, advocacy, solidarity, mutual-aid and collective mobilization, I suggest, offer additional and fuller expressions of citizenship and democratic [politicised] empowerment. These commitments were, in part, why we started this journal (some 10 years ago now) with an explicit activist education agenda. It seemed necessary at the time because these discussions were not part of mainstream science education research and practice.

The murder of George Floyd by Minneapolis police is another sickening, brutal and needless death. This has happened before, far too many times. And it continues, including the recent shooting in the back (twice) of Rayshard Brooks just two days ago. In the US, on average the police kill 3 people per day (1 every 8 hours or so)²³. Black people are three times more likely to be killed than White people.²⁴ The film “13th”, released long before these recent incidents, prophetically ends with a video of choking by the US police with the cries of a restrained Black victim calling out that they are “unable to breathe”. As you note, Canada also has a race-based problem with a history of police violence and killings especially against Black and Indigenous Peoples²⁵, including the recent high-profile filmed attack on Athabasca Chipewyan First Nation Chief, Allan Adam.

²² Carter, L. (2014). The elephant in the room: Science education, neoliberalism and resistance. (pp. 23-37) In L. Bencze & S. Alsop (Eds.) *Activist Science and Technology Education*. Dordrecht: Springer.

²³ Wilson Gilmore, R. (2020). Ruth Wilson Gilmore makes the case for abolition (an interview with Jeremy Scahill). *The Intercept*. Available online at: <https://theintercept.com/2020/06/10/ruth-wilson-gilmore-makes-the-case-for-abolition/>

²⁴ Statista (2020). Number of people shot to death by the police in the United States from 2017 to 2020, by race. Available online at: <https://www.statista.com/statistics/585152/people-shot-to-death-by-us-police-by-race/>

²⁵ Simpson, N. (2020). Canada has race-based police violence too. We don’t know how much. *The Tyee*. 2nd June. Available online at: <https://thetyee.ca/Analysis/2020/06/02/Canada-Race-Based-Violence/>

Black and Asian people are up to 50% more likely to die from COVID-19²⁶. In Canada, race-related data has not even been gathered other than anecdotally, which also paints a similar picture. This is another education moment: an invitation to discuss the presence and absence of data (and the associated politics of evidence). It is also an invitation to question reproductive mechanisms of wealth, power and privilege. Whose lives matter, whose voices are being silenced in this pandemic, being overlooked in policies and practices, including medical treatments, as well as the testing, development and hopeful rollout of COVID-19 vaccinations

The associated uprisings in the US by Black Lives Matter and those held in solidarity in many countries around the world have brought these injustices home. The BLM matter movement has ripped open assumptions and orthodoxies upon which society has rested and in so doing ushered in new sensibilities, aesthetics, politics, ethics and responsibilities. They have forced those of us working in [science] education to take a deep look at ourselves and reflect on ways that our practices and silences are implicated in sustaining White, patriarchal supremacy and anti-Black racism. There have been immediate responses and science educators and advocates have made statements condemning police brutality and recognized the need to systemically dismantle systems and practices of racism in science.²⁷ It is important that all science education organisations join in solidarity. I am thinking here of a number of large professional research organisations which have not, as yet, released statements about BLM or COVID-19. There has been much discussion of reforms in universities, including faculties of education (our own included) and faculties of science. Curriculum resources are now being widely circulated, including the *Teaching for Black Lives* resource²⁸ and other publications by rethinking schools, which play a central role in my preservice teaching. These resources add to the work of curriculum innovators and researchers who have worked for many years with anti-racist commitments. A publication that influenced my early work was Gill and Levidow's *Anti-Racist Science Teaching*²⁹ and last year my graduate students really enjoyed reading Angela Saini's book, *Superior: The Return of Race Science*³⁰. These publications forge connections between science, colonialism, capitalism and racism. It is important to recognise that, although this moment is a rupture and feels new, there are still education resources that can offer commentary and helpful teaching activities. I also want to acknowledge and celebrate all those teachers and social justice organisations working on the ground, struggling day-by-day for better worlds. These acts, these alternative histories if you like, can be too easily overlooked in moments of radical change or "the coming of the new" to use Hannah Arendt's words.

You conclude by raising environmental issues. Here, I am reminded that the BLM and solidarity demonstrations bring people together with multiple struggles in defiance of allied injustices, subjugations and oppressions. These include struggles against environmental racism. It is also important to acknowledge feminist, LGBTQ2, anti-capitalist, Indigenous, anti-colonial, class, and environmental justice intersectionalities as well. The BLM movement invites explorations of whose lives matter in environmental policies, practices and politics. This includes lots of important questions, such as: who has access to green spaces, clean air and water. Who has access to fresh food and produce? Who has access to transportation? Who has access to scientific expertise and environmental monitoring? Who lives in polluted and toxic environments? Who is most affected by climate change? This type of critical place-based analysis offers a

²⁶ McKay, H. (2020). Black and Asian people in England more likely to die from COVID-19, public health report says. CBC, Jun 2nd available at: <https://www.cbc.ca/news/world/coronavirus-Black-asian-england-1.5594608>

²⁷ March for Science (2020). Unite behind the science. Available online at: <https://marchforscience.org/>

²⁸ Watson, D., Hagoopian, J. & Au, W. (Eds.) (2020). *Teaching For Black Lives*. Milwaukee: Rethinking Schools Publication.

²⁹ Gill, D. & Levidow, L. (1987). *Anti-Racist Science Teaching*. London: Free Association Books.

³⁰ Saini, A. (2019). *Superior: The return of race science*. London: Penguin.

rich basis for educational explorations in science, health and environmental justice education. Here, I am reminded of the ENRICH (Environmental Noxiousness, Racial Inequalities and Community Health) and their inspiring work publicly disclosing locations of industrial polluters, which are disproportionately located next to Indigenous communities, communities of colour and working poor communities in Nova Scotia Canada. Monitoring and disclosure, I think, are an important part of scientific literacy and citizenship.

There is so much to admire in the educational work of feminist and racialized environmental organisations and Indigenous groups: to name a few in Canada and the US - Indigenous Environmental Network [Canada]; Indigenous Climate Action [Canada]; ECOGirls [Ann Arbor]; the Radical Monarchs [Seattle]; and Rooted and Rising [Toronto], which I am so proud to be a part of). These organisations stress the importance of human and non-human lives. They give environmental stewardship and environmental education a political edge, which it too often lacks. I still maintain that science education and new social movements have so much in common and can gain so much by working more closely together. This inspires my educational work. In the Faculty of Education at York University, I stand by our decision, taken nearly a decade ago now, that teacher candidates (in all grades and subject areas) conduct their first practicum in a community organisation, including many organisations with explicit social and environmental justice agendas. This provides important perspectives and experiences with which to center the teaching profession.

That is probably more than enough. I sense that it is time to bring these discussions to a close and hand over the baton to you for the last time. I conclude by returning your questions: what do you see as some of the implications of the recent events for science education and activism? And in returning to our opening discussions, what questions do we need to embrace as we move forward in our work as science teacher educators and researchers? As always, Darren, I welcome your thoughts.

Darren (Sunday June 21st): Thanks Steve for your insights and wisdom during this conversation. What started as an exercise of two science education scholars to articulate what post-COVID-19 science education might/could/should look like has turned into a conversation because we have realized in our ponderings that this sort of top-down prescription is exactly what is not needed for teachers and students to engage in activism relevant to the pandemic. What has become clear in our discussion, which I think you bring to a point very cogently in your last response, is the need for communities to consider and discuss the politics surrounding the pandemic, racism, and school science, rather than look to technoscientific solutions, which in this case might be represented by curriculum and teaching resources developed by ‘outside’ agencies or scholars.

Building on your argument, Steve, I see the COVID-19 pandemic creating an ‘opening’, into which many agents are rushing, to fill with ‘expertise’, be it scientific, technological, economic, or educational, to name a few. Who can move the fastest, who is already in position, and who has the resources to fill the space is already a function of privilege, with the forms of capital conducive to solutions and production of knowledge and practices historically aligned with those that have come before, such as the White patriarchal systems of knowing and knowledge you write about.

What both the recent Black Lives Matter protests, and the pandemic share is that these diverse moments embody characteristics of an ‘event’: That is, they have happened rapidly; they throw institutions and role definitions into turmoil or disarray; their antecedents often seem insufficient to explain their

emergence and amplifications; their settlement is uncertain; and they make a real difference in the world³¹. These events started out of apparent uncertainty and, particularly with the pandemic, foment greater uncertainty as they evolve. These events have emitted contagious and infectious energies. Numerous social institutions appear to be at risk of radical rapid evolution and change. Education/science education is one of these institutions. The pandemic has startled, provoked and energised; it has also disturbed, alienated, over-whelmed and incited resentment against the place and prosperity of some human beings relative to others.

We are currently living at a time of real turmoil and uncertainty. Moments such as this both demand and foster incidents of real creativity, a novel response to a condition from the past that engenders a new result that is less than chance and more than simple determination. In our disequilibrium, notions such as criticality, asymmetrical rhythm, vague intensity, system resonances, self-organisation, amplification, emergent causality and real creativity become pertinent concepts to describe and understand an *incipience*, an impending fundamental change in the fabric of the social order, resulting from the event. Unexpected events, such as the pandemic, creates a flurry of discussion, such as the one we are having, between those who think politics can be comprehended in classic categories of explanation, those who wish they could believe that but actually cannot, those who adopt qualitative or interpretive approaches, and those, perhaps becoming prominent again, who think that attention to the event carries you into territory that may not be *entirely* reducible to any of these perspectives. I think what we have argued in our conversation adheres to the latter point, which is both thrilling in its possibilities, and intimidating in its uncertainties.

What conversation does is demand that we pause and consider the very systems of privilege and power that have gotten us here, and how these affect the everyday lives of people and communities, before rushing forth with technoscientific solutions that reproduce oppressive systems. The void in education created by the pandemic already has several actors awaiting, and pushing to fill the void, such as the Ontario government, which has tried to make online learning a priority in the province, to the dismay and resistance of many teachers and students. You and I, Steve, are not the only people thinking about COVID-19 education, and many are likely much further along, with unit plans, PowerPoints™, and resources already developed. We can hope this education has been produced with socio-political aspects of the science of the pandemic considered first and foremost. Since this is an emergent area, however, it does cause one to wonder how dynamic and unknown socio-political aspects of the pandemic might have been captured by these precocious educational products. Who have they been developed by, and for what purpose? These are questions that educational communities are hopefully asking before implementing them.

Rather than see the opening created by the Pandemic as an event that will simmer and fizzle for a while before settling down to the familiar rhythms and routines of (neo)liberally influenced school science – COVID-19 edition, I'd rather explore the possibilities of this time as providing the energies and disequilibrium conducive to an incipency in science education where we can finally address historic oppressions related to socio-economics, race, gender and sexuality. In other words, we might see this as an opportunity for science educational reforms that pays attention to Black, Indigenous, gender, sexual and other marginalized identities in ways that stick. In order to achieve this, I come back to my earlier point of the need for the voices of teachers and students to lead the conversations about science education in a time of COVID-19. The 'experts' in this conversation must be those who's everyday lives are entwined

³¹ Connolly, W.E. (2013). The 'new materialism' and the fragility of things. *Millennium: Journal of International Studies*, 41(3), 399-412.

with the science education of which we are speaking. What do the teachers and students in marginalized Black communities need from science education in a time of COVID-19? How do we, as science educational scholars, contribute to an event in the making in which teachers and students voices are the driving factors in science reforms that are oriented towards equity, social and environmental justice? The coincidence of Black Lives Matter with the Pandemic has amplified energies and provided models of what community generated social activism for COVID-19 education might look like. The George Floyd murder set of a cascade of stories of Black lives that have been oppressed in similar ways, evolving into social awareness of institutionalized racism. This begs the question: How might groups of public-school teachers and students mobilize their stories and experiences during the pandemic, revealing to the public the fabric of institutionalized racism and other oppressions in school science education, that reproduce inequities in the way students and teachers experienced the pandemic? As we have seen with BLM, the turmoil and disarray, or disequilibrium offered by recent events may have primed society for radical social change. Indeed, we seem to be at an auspicious time for such change. It is my hope, Steve, that our conversation might inspire others, between teacher, students, and authorities involved in public school education, that enable community-grounded science education reforms in a time of COVID-19 that, in addition to addressing questions of science literacy related to the epidemic, finally recognize the differential ways science education must be leveraged to address social inequity.