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 pandemic\(^1\). 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!

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).

such a dramatic statement, Ms. Thunberg could be echoing advice from Noam Chomsky, who said — as also recently stressed by the Bulletin of the Atomic Scientists — 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 (earthy) 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

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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.](image-url)
‘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 ↔ 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: Sideline 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)buses 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

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 resilience. 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 resilience. 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 ¿conomicus (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,

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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 spirit. 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=0kIhBgQAw3U
“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? 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, ⁹ To learn more about STEPWISE, visit: www.stepwiser.ca

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Figure 3: STEPWISE Schema & STSE Relationships.
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
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/2GIgtf. With perhaps further insights from teachers (Teacher Teacher, 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

![Designing a ‘WISE’ Tent](image)

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/yb45c8mv.

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
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 r-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 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 Gaïa 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 societies.”

References

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


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