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FORUM

Stepping into STS literature: Some implications for promoting socioecological justice through science education

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Abstract
Inspired by Torres-Olave and Bravo's original paper, entitled 'Facing Neoliberalism through Dialogic Spaces as Sites of Hopes in Science Education: Experiences of two Self-Organized Communities', the present essay considers potential contexts to resist neoliberal models of science education. This paper discusses affordances of themes and notions from domains of Science and Technology Studies (STS) to inform STEPWISE-informed pedagogies (Bencze 2017) that engage with (bio)political analyses of technoscience for social and environmental justice. Notions from STS highlighted include: 'sociotechnical imaginaries', 'emotive actants' and 'anthropocentric temporalities'. We illustrate these in relation to contemporary science and technology products and practices to highlight futures and subjects that they foreground and foreclose. We end by considering how such STS notions may extend areas of interest within science education (scholarship), through: 1) situating fields of (techno)science within their social and political sphere, 2) meeting future studies that seek to problematize individual perceptions of futures, 3) considering different forms of environmental activism beyond (personal) actions and 4) contributing to an 'affective' science education.

Keywords Science education · Social and ecological justice · Science and technology studies

This review essay addresses issues raised in Betzabé Torres-Olave and Paulina Bravo González (2021) entitled, *Facing neoliberalism through dialogic spaces as sites of hopes in science education: experiences of two self-organised communities* (https://doi.org/10.1007/s11422-021-10042-y)

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Introduction

Roth (1998) argued that there is almost a 'natural match' between fields of Science and Technology Studies (STS) and science education. STS fields offer science education important educational aims that reflect "situated, contingent and contextual nature[s] of science, while also acknowledging the diverse range of communities and locations where science is created and used" (McGinn et al. 1999, p. 17). In this paper, we continue to engage (with) those affinities, seeking out productive lines for re-imagining a science education for social and environmental justice.

We felt called to highlight this aspect of our current work after reading Torres-Olave and Bravo's original manuscript, entitled 'Facing Neoliberalism through Dialogic Spaces as Sites of Hopes in Science Education'. Their work resonated with us in multiple ways. We meet the authors' concerns around a science education governed by "a neoliberal logic [that] squeezes out of us the ability and freedom to act and think collectively and which takes our time, our labour and, even at times, our dreams" (p.). We join them in their call for science education practices that "provide pedagogical conditions and experiences for critical and engaged citizenship" (p.) and that "act and engage with different settings in solidarity" (p.). In reading their work, we were reminded of Biesta's (2015) words:

> The most important question for us today is no longer how we can rationally master the natural and social world. The most important question today is how we can respond responsibly to and how we can live peacefully with what and with whom is other (p. 15).

We carry such sentiments into our work and want to thank Torres-Olave and Bravo for reaffirming those commitments when describing their research with two self-organized science teacher communities in Chile. We read their research as a form of "practicing ethico-political hesitations" (Wallace 2018, p. 7) in science education, when authors raise questions about larger aims of science education in neoliberalism-influenced Chile. In doing so, they begin to "engage in the critical task of identifying, examining and addressing the multiple ways in which science education continues to uphold problematic enactments of power" (Higgins et al. 2019, p. 157).

Foregrounding dialogue as their theoretical and methodological orientation was equally refreshing for us, allowing us to re-encounter science education and science education research as necessarily relational and process-oriented (less preoccupied with science outcomes and extractive logics, see also Pierce 2012). This is, of course, not to suggest a binary between process and product but to suggest that, perhaps, preoccupations with measurable learning outcomes and discourses around (teaching) efficiency might have overpowered other ways of imagining science education and science education research. We were drawn to the authors' construal of dialogue in science education and science education research as an *affective* space of "love, hope and collective care" (p.) with material implications. Affective and material dimensions of dialogues allow us to encounter 'performative nature of pedagogies' (Weinstein 2008), beyond mere didactic and cognitivist perspectives that retain dialogue as a sole representational practice. In that vein, we wonder how dialogue, as a performative pedagogy, might "emphasize the playful, the fictive and the bodily at the intersection of science and education" (Weinstein 2008, p. 395). We agree that "dialogues are democratizing" (Torres-Olave & Bravo, p.) when they take place across different settings, moving unpredictably, growing in different directions, potentializing new horizons for thinking, being and relating. This is how we arrive into this discussion, not

as a direct response to Torres-Olave and Bravo's work, but moved by their contribution, to reflect, yet again, on possible sites for resisting neoliberal models of science education. With that, we extend our gratitude to the lead editor for enabling this space and maintaining this larger dialogue.

We begin this essay by situating our interests in STS literature, discussing our careful approaches stepping into this field of scholarship. Next, we give an overview of existing research that draws on fields of STS (also known as science studies) to inform fields of science education. We expand on those connections, noting that (bio)political economies of technoscience—one area within fields of STS—remain modestly articulated within science education and science education research (Carter et al. 2017). Later, we present three interrelated STS notions that re-engage with (bio)political analyses of technoscience: 'sociotechnical imaginaries', 'emotive actants' and 'anthropocentric temporalities'. We consider how such STS notions may extend areas of interest within science education, namely through: 1) situating fields of 'technoscience' (Sismondo 2008) within their social, political and material contexts, 2) meeting fields of future studies, which seek to problematize individual perceptions of futures, 3) considering different forms of activism beyond (personal) actions and 4) contributing to an '*affective* science education' (Alsop 2016).

Stepping carefully into STS literature

Our present contribution stems from a larger pedagogical and research project, 'STEPWISE' (Bencze 2017). STEPWISE (acronym for Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments) prioritizes: 1) teaching students about 'power' related socio-scientific issues (SSIs) and 2) supporting students as they develop an ethical praxis vis-à-vis individuals, societies and environments. One of STEPWISE's recent research endeavours is to translate claims from STS literature into pedagogical applications for science education.

Stepping into this literature, we were particularly oriented to theoretical claims and case studies that carry within them possibilities to further enrich and actualize STEPWISE-like approaches in science education contexts; specifically, we approached STS literature that sought to portray fields of science and technology as entangled in complex webs of relations involving other social players (e.g. private corporations, governments) and that problematize issues of power mostly connected to neoliberal forms of governance and biopolitics (defined broadly as intersections between biological and political lives, see Carter et al. 2017). On the other hand and keeping with STEPWISE's call for active public engagement on socio-scientific issues, we have been equally interested in convergences amongst STS literature and social movement studies (Hess 2015) to highlight roles of citizens in scrutinizing and reforming various technologies (e.g. those related to biotechnology). Such lines of inquiry are still being explored in our work and won't be included here; instead, we focus on studies that addressed, to various extents, issues related to neoliberal governance and (bio)politics in technoscience.

The title of this section 'Stepping into the STS literature' may imply an inside-outside duality, suggesting that fields of STS and science education are discrete and bounded fields of research/practice. This oversimplification is not intended. We recognize how STS scholars/educators are already 'doing' science education, perhaps inviting further inquiries into what science and science education might mean for an STS practitioner (e.g. Birch 2017).

In STEPWISE and before setting to deliberately review STS research, we have long been influenced by theoretical insights from those fields. For instance, we have been encouraging students to map relationships amongst science, technology, societies and environments drawing on actor-network theory (Latour 1996) to include non-humans and semiotic actants and to acknowledge their often-hidden roles in stabilizing socio-scientific networks (Bencze et al. 2018). Actor-network theory could also inform how students might take actions on socio-scientific issues (e.g. Ramjewan et al. 2017). Thus, in a way, we step into STS literature, from past encounters.

For the past year and a half, we have immersed ourselves in this literature, negotiated collective understandings and began translating STS claims into pedagogical tools (e.g. instructional videos) to be further negotiated with science teachers and their students. We turned to academic articles in several major STS journals, including: *Social Studies of Science, Science as Culture* and *Science, Technology and Human Values* (2010–2020), amongst other STS publications and conference papers. For our present purposes, we wish to contribute with few illustrative concepts that were gleaned from our ongoing explorations of this broad and diverse literature and that might help cultivate different kinds of relationships within science and technology education (Alsop 2016). We invite you to treat those concepts as conversation starters, noting that our approach is careful and propositional/invitational (Springgay et al. 2018). This is crucial as we attempt to steer clear from claiming authoritative knowledge over a (new) research field and as we resist urges to *extract* STS claims that are 'useful' to science education. Such extractive tendencies can leave us in an uneasy predicament, when considering our goals working towards socially and environmentally just practices through science education. In that sense, we urge our readers to take our contribution here as a work-in-progress, a beginning of a dialogue that ardently awaits participation of STS scholars, science teachers, educators, scholars and students (next phase of our STEPWISE project), affecting and affected by a collective 'cross-pollination' of knowledges.

Parsing through contributions from STS and their various modes of uptake in science education (research) may reiterate a distinction between those two fields. There lies another point of contention and probably, even, of translation. There will always be ontological, axiological and epistemological gaps/dilemmas when translating knowledges between two disciplinary fields. STS scholars appear to refrain from engaging with school science on grounds of its interests in 'ready-made' science (e.g. science laws and concepts), which might be incongruent with STS's larger interests in 'science in the making'. Weinstein (2008) states that 'schools have consistently been viewed in science studies as static, consensus based, free of conflict and ultimately banal and not worthy of research' (p. 391). This might seem discouraging. At the same time, it prompts us to consider how we might navigate those epistemic barriers in our future collaborations with STS researchers/practitioners. Other ontological/axiological gaps may exist as we translate STS claims into pedagogical materials. In our case, seeking to inform STEPWISE-like approaches, we had, at times, to make various decisions based on what's 'appropriate' for school-aged students learning science. In appealing to science teachers, we might feel incessant urges to make 'science' connections visible when producing pedagogical materials, returning to conceptions of science as 'ready-made' and somehow missing the mark on 'science in the making'. For those reasons, we believe that being in active and sustained conversations with STS scholars and science teachers might help us collectively consider those various dilemmas and interrogate those assumptions in acts of translation.

STS and science education

STS scholars are mostly sociologists, historians, anthropologists, philosophers who study scientists and engineers and science-in-action, broadly understood (Sismondo 2008). Fields of STS are multilayered and manifold, with diverse foci that range from studying nature and practices of science and technology, their various impacts and forms of control. Some STS research focuses on reform or activism, critically addressing policy, governance and funding issues, to try to "reform science and technology in the name of equality, welfare and environment" (Sismondo 2008, p. 13). Despite (or perhaps, because of) their diversity, such fields are fueled by basic understandings of science and technology as discursive, social and material practices (Latour, 1987). Roth et al. (1998) discussed how research findings from fields of STS could support students in developing 'authentic' views about nature of science and science practices. Students, for instance, might depart from viewing representations (e.g. graphs and models) as 'sanitized' versions of science knowledge (Bowen et al. 1998), recognizing instead how "knowledge is *practiced* [and not merely constructed] within structures, processes and environments" (Cetina, 2009, p. 3).

Two special issues of the journals *Research in Science Education (1998)* and *Educational Studies (2017)* are purposefully dedicated to highlighting affinities and possibilities between STS research and science/STEM education. They review STS theoretical tools and methodologies with implications for 'creative and critical' (Freitas et al. 2017) science/STEM education research (e.g. Buxton et al. 2017), climate change education (e.g. Verlie 2017), sociocultural science education (e.g. Calabrese-Barton 1998) and teaching about nature of science (e.g. Costa et al. 1998).

Weinstein (2008) argues that social studies of science (likely in reference to STS research) offer science education four framings of science: 1) *science as investigation*, this is science as inquiry as it happens in laboratories and what's social is limited to micro interactions between lab workers and meaning-making practices, 2) *science as work*, whereby, science is more than just laboratory work and what's social extends to writing grants, going to conferences and building and contesting knowledges with others, 3) *science as enterprise,* under this view, "profit, patents, political economy, interest, lobbying, legislation and funding all emerge as part of science" p. 395) and 4) *science as culture* expanding what "science means when understood as a culture in relation to social movements around diseases, environmentalism, human objectification" (p. 395).

For a glimpse at some recent STS research preoccupations, the call for papers for a conference of the Society for Social Studies of Science (4S, 2021), a conference generally attended by STS scholars and practitioners, is worth quoting here:

> What does it mean in practice to strive towards good relations as humans, with technologies, in our modes of knowing, within environments, across distance, and with other-than-humans? When we speak of good relations, we address ethics of care, frameworks of responsibility, and solidarity that span disciplinary and subject boundaries. We invite these reflections in relationship to the insurgence of white supremacy, the intensity of grief, and continuing struggles against long standing oppressions at personal and structural scales. […] We invite scholarship that critically addresses the methods and practices that maintain oppressions within technoscience.

When encountering those words, we are immediately tempted to consider similar roles for a science education that helps students "strive towards good relations as humans, with technologies, in our modes of knowing, within environments, across distance and with

other-than-humans". This interest appears to be temporally significant for science education. Drawing on metaphors of 'portal', Alsop and Bencze (2020) invite us to see our current times as opportunities to re-imagine how we might do, live and relate to science and technology education amidst glaring social inequities and lingering ecological distress. The portal "vividly captures 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" (Alsop & Bencze 2020, p. iv). We see ourselves moving with this portal, turning more intently to STS literature, as we continuously strive within our research and practices (see also El Halwany et al. 2020).

(Bio)Political economies of technoscience education

STS research does not only inform pedagogical projects but could provide frameworks to analyse how students become "enculturated in modern, techno science-centered society" (Weinstein 2008, p. 397). This is, purportedly, a focus of a special issue of the journal *Cultural Studies of Science Education (2017),* addressing intersections between biopolitics (an analytical tool used in STS scholarship, see Birch 2017) and science education. Carter et al (2017) view "schooling, of which science education is a part […], a biopolitical system that (re)produces and regulates the economic subject" (p. 764). Bazzul (2017) uses microanalyses of everyday practices related to lab assessment tasks and discourses around careers in science to map how students are constituted as "self- investing, depoliticized 'subjects of (science) labor" (p. 874). Elsewhere, Kirchgasler (2018), drawing on STS-inspired constructs such as 'biomedical citizenship', problematizes science education for citizenship through a cross-examination of health education science pedagogies in Philippines (as a US colony) and a general science course in the US. She analyses how science education programmes, through their assessments of hygiene and health, produce "exclusionary boundaries [that] mark some as pre-qualified citizens and others as needing intervention to be recognized as fully responsible human agents" (p. 118).

Critical perspectives on science/STEM education raise (normative) questions that pertain to kinds of citizens/subjects/values and futures imagined through science pedagogies and practices. In their analysis of the Next Generation Science Standards, Hoeg and Bencze (2017) argue that such standards aim to prepare competent STEM subjects able to participate in future market societies. De Roock and Baildon (2019) show how STEM education initiatives through online means in Singapore serve to recruit students into a "neoliberal figured world of learning, work and citizenship" that rests on a "narrowly imagined disciplined society and workforce appealing to global capital" (p. 285). In the next section, we shift our attention from STEM education to fields of STEM to discuss how they participate in production of subjectivities and imaginaries that support and are supported by advances in those fields.

(Bio)Political economies of technoscience

Political economies of technoscience refer "to political-economic processes, practices and contexts that inform fields of science and technology" (Birch 2013, p. 51). It is about recognizing how "specific economic epistemic claims (i.e. neoliberalism) have dominated ethical, political and social agendas and shaped technoscientific pathways" (Birch 2013, p. 53). Within this line of work lies inquiries into "ways science (or knowledge of the natural

world) is embedded, embodied and enacted in particular political conditions" (Freitas et al. 2017, p. 553). Political economies of technoscience meet with studies of *biopolitics*, taken here to be "convergence between biological existence, technology and the socio-political where power compels life to be administered, regulated, optimized and controlled" (Carter et al. 2017, p. 762).

For instance, Vora (2015) examines how gestational surrogacy (with various advances in assisted reproductive technologies) turns into an outsourced labour that supports life in the United States at the expense of lives of people in India. She proposes that ways we think about bodies and bodies' parts (in this case, the uterus) as disembodied parts that are alienated from subjects (with the outsourcing of gestational surrogacy) are deeply entangled with histories of colonialism and labour allocations that rest on racial and gendered discriminatory practices. Clough (2008) looks at how digital technologies (e.g. technologies of surveillance and security) "operate to race populations" (p. 19), where bodies' affects (e.g. face recognition, body heat, neural imaging) are monitored and deployed in biopolitical control. In other words, body parts become 'punctualized' (Callon 1991), reduced to their organismic functions, to enable their circulation in economic markets. In her book on *The Economization of Life*, Murphy (2017) argues that studies of population eugenics rest on quantitative racist practices that reduce life to its potential economic contributions. Illustrating the economization of life, Murphy discusses how dreams of formal education for girls in Bangladesh were entangled with surges in reproductive technologies to control for 'undesired' birth, while producing a wealth of data for population control. This research overview begins to gesture towards possibilities for a science education that engages with biopolitics of technoscience, presenting opportunities for discussing racial and gendered disparities in relation to technoscience practices. In the next section, we turn to specific conceptual notions from fields of STS that further highlight how "life has become a phenomenon open to problematization, reinterpretation and reconfiguration as a result of modern bioscience and, in the specific context of the bio-economy, modern capitalism" (Birch 2017, p. 918).

Some STS concepts

In this section, we present three notions drawn from our readings of the STS literature: socio-technical imaginaries, emotive actants and anthropocentric temporalities. We illustrate each notion in relation to contemporary science and technology practices and products to highlight kinds of futures and subjects that they appear to foreground and foreclose.

Sociotechnical imaginaries

'Sociotechnical Imaginaries' (SIs) (Jasanoff 2015) refer to "collectively held, institutionally stabilized and publicly performed *visions of desirable futures* (…) attainable through and supportive of, advances in science and technology" (p. 4, *our emphasis*). We view sociotechnical imaginaries to constitute and be constitutive of values and principles that bind sets of living & nonliving actants (Latour 1996) in ways that serve particular purposes. Indeed, STS scholars push us to think how human capacities – to learn, to be healthy, to work, to reproduce –"are configured as forms of capital open to speculation not only for individuals and their families, but also for states and transnational investment" (Adams et al. 2009, p. 259). Consider, for instance, how self-tracking devices that constantly

measure our health, physical activity, sleep, screen time, etc., normalize obligations to stay informed about possible futures, as features of 'good' and virtuous citizenship (Lupton 2016). They leverage feelings of incompleteness and prescribe narrow conceptions of agency, wellbeing and citizenship (Wade 2018). They help shape and justify increasingly growing markets that commercialize self-care, while over-responsibilizing subjects over their own wellbeing (Schüll 2016). Moreover, data collected as part of those self-tracking technologies are used by agencies and private organizations, leading to increased surveillance of supposedly 'personal and privatized' data (Lupton 2016). With 'pleasures' and conveniences accompanying self-tracking individual behaviours (Wade 2018), incentivized surveillance practices appear to become increasingly normalized (Zuboff 2015).

Emotive actants

Emotive actants are "actants intensifying experiences and expressions of human feelings" (Stark 2019, p. 118). Human feelings extend to sensations, moods and emotions mobilized for "technoscientific, economic and political ends" (Stark 2019, p. 121), such as management of (emotional) labour, consumption and health. The term 'actant' is borrowed from Actor-Network Theory (ANT) to highlight various entities (human, non-human, material and semiotic) that interact as part of social landscapes in which science and technology operate (Latour 1996). In advancing 'emotive actants', Stark (2019) argues that, while affect and emotion are clearly relational and agentic, they "have not always been well explicated in relation to ANT approaches" (p. 118). Far from being personal and individual, emotive actants appear to drive our attachments to particular *sociotechnical imaginaries* (e.g. consumerism, individualism, nature as resource, etc.). One current example is sentiment analysis algorithms. Andrejevic (2011) notes how sentiment analysis and mood analysis' applications [both being products of science and technology fields] "troll through Twitter feeds, blogs, social networking sites, online forums, bulletin boards and chat rooms, probing the emotional pulse of the Internet" (p. 610). It is important for students to recognize how their interactions with various technologies feed into "a data-driven fantasy of control in the *affective economy*, so that the more emotions are expressed and circulated, the more behavior is tracked and aggregated, the greater the ability of marketers to attempt to channel and fix affect in ways that translate into increased consumption" (Andrejevic 2011, p. 615).

Anthropocentric temporalities

Anthropocentric temporalities in technoscience can be mapped to practices and products of science and technology (e.g. fertilizers) that favour human temporal timescales over other timescales for capitalist gains. One manifestation of such anthropocentric temporality, according to Puig de la Bellacasa (2015), may be traced to practices that continue to view the soil as an inert resource. She invites us to think of 'time' from the perspective of earthworm communities and ways artificial fertilization of soils aimed at accelerating yield would be a slowing down of development of worms and other essential soil communities, while simultaneously leaving farmers feeling the pressure of productionism (Shiva 1991). She engages with soils at the intersection of science, culture and community to "emphasize aspects of scientific practices and narratives that contribute to the formation of new ecological cultures of care for the non-human world" (de la Bellacasa 2019, p. 392).

Phillips (2020) explores intertwining of multiple temporalities and timescales through attention to a more-than-human practice: beekeeping. Resisting notions of a unitary natural time, she notes how "urgent pleas to 'save the bees' in the face of fears of extinction and lost food security […] co-exist with intimate tempos and seasonal coordinations of beekeeping" (p. 316). She gives an account of how "the physical and emotional work of beekeeping means becoming attuned to hives over time, altering one's rhythms to coordinate with those of bees and feeling how one is altered through repeated encounters" (p. 319). Coordinating more-than-human temporalities gives "a sense of shared aliveness" (de la Bellacasa 2019, p. 391) that could transform humans' relationships with the non-human world.

Resonances of STS concepts with science education (research)

Some of the STS research that we began to review here could offer science education some pedagogical openings for considering how 'biological life […] is enmeshed with political life' (Carter et al. 2017, p. 762). Science educators and teachers may choose not to refer *literally* to STS notions (such as 'socio-technical imaginaries'), but they may be inspired by their pedagogical *resonances* within science and environmental education. We discuss such pedagogical resonances in relation to four areas of interests within science education and science education research: nature of (techno)science, future studies, activism for social and environmental justice and studies of affect and emotions.

Nature of (techno)science

Literature from STS is ripe with notions and theoretical constructs that could provide science education with conceptual tools, contemporary examples and relevant cases for engaging students 'critically with the political, social and economic implications of science and innovation' (Birch 2017, p. 924). This is congruent with most education and educational research targeting 'nature of science for social justice' (e.g. Yacoubian et al. 2020), socio-scientific issues (SSI) education (Sadler et al. 2011) amongst other 'science in context' initiatives (e.g. Bencze et al. 2020), as well as critical perspectives on STEM education (e.g. Freitas et al. 2017). STS foci on fields of 'technoscience' (and not merely science) could further reclaim discussions around nature of technology as inseparable from discussions around nature of science (Roth 2001). This could further actualize a 'technoscience' education (Sismondo 2008) that could transcend science's epistemic privileges over fields of technology, while equally advancing (non-reductionist conceptions of) technologies in relation to their material effects and affects. This may involve helping students move away from technological determinism and from simplistic understandings of machines shaping our worlds. On the other hand, bio-concepts in STS literature (see Birch 2017) could help leverage roles of material technoscience cultures 'when materiality has been too long ignored' in science education (Scanterbury et al. 2019). This can have implications for grappling with new modalities of citizenship that emerge with the digital age for instance, when bodies and lives are turned into data (e.g. through trends such as 'quantifying the self', see Lupton 2016).

Future studies

STS researchers work with a range of concepts related to futures and temporalities that could carry some implications for future studies in science education. Discussions of possible, probable and preferable futures as part of school science are believed to enhance students' critical engagement with socio-scientific issues (Jones et al. 2012). Lloyd et al. (2004) argue that future concepts and processes empower individuals in the 'present' by providing positive images of possible futures, while encouraging altruistic dispositions that consider needs of future generations. In getting students to build their own versions of future scenarios, there are, however, inherent risks that students maintain 'desired' futures dismissing important players (e.g. technoscience fields, governments, business leaders, insurance companies, media) and their roles in shaping what we ought to desire. Notions from STS presented here invite critical inquiries into 'default futures' (Inayatullah 2013) we are given through science and technology, so students can challenge them and imagine anew how science and technology may support non-orthodox, non-Western futures that are decolonized and that lie outside economic conquest of time (Inayatullah 2013). For instance, thinking with anthropocentric temporalities can help students problematize socio-technical imaginaries that rest on (human) progress, efficiency, productionism and accumulation (Tsing 2015). We are equally tempted to consider how future thinking in science education could strive to 'diversify and "thicken" accounts of times and temporalities (…) to gain new insights into "small kingdoms of worldliness"' (Phillips 2020, p. 316) and what this could mean for environmental/science education.

Activism for social and environmental justice

While concepts presented here do not explicitly address social movements in relation to technoscience, they appear to espouse a necessity for publics 'to pursue greater oversight of technoscience at a time when they otherwise risk being turned into compliant consumers' (Birch 2017, p. 924). When students become attuned to complex arrangements of actants involving science and technology, they might come to equally appreciate needs to take actions for social and environmental justice that go beyond personal and individual behavioural change (e.g. recycling, biking). According to Carter (2011), there are risks that small-scale individual actions may perpetuate neoliberal discourses and related imaginaries of human agency, choice and individuality. Literature from STS discussed here offers ways of re-thinking social and environmental activism along practices of 'critical care' (Martin et al. 2015) to enact new (affective) relationships with more-than-human worlds. A critical practice of care would 'insist on paying attention to privileged position of the caring subject, wary of who has the power to care and who or what tends to get designated the proper or improper objects of care' (Martin et al. 2015, p. 12). For instance, thinking with anthropocentric temporalities could help students appreciate limitations of 'quick technoscience fixes' by considering how they reiterate traditional linear modes of technical rationality (Carter 2011). Other implications include problematizing modes of environmental 'care' premised on urges to 'save', 'protect' and 'manage' nature by discussing how they continue to prioritize human timeframes and nature-culture divisions (Martusewicz et al. 2010).

Affect in/of technoscience (education)

Excerpts from STS literature reviewed here can push students to follow 'affective politics' (Ahmed 2014) connected to products of science and technology (such as hope, fear, anxiety) that intensify and potentialize our attachments to human-centric visions, practices and ways of knowing, while foreclosing other ways of being with more-than-humans. Far from seeing emotions as personal and private, students can become attuned to political dimensions of emotions (Zembylas 2016) and to our affective orientations to products and practices in science and technology. The purpose is not to become immune to those affective orientations (is that even possible?) but to enable students to transcend Cartesian divisions between thinking and feeling towards thinking as feeling and feeling as thought (Raymond 2015). This could begin to respond to calls for an '*affective* science education' (Alsop 2016), by including representations of affect in science and education and by experimenting with creative and transformative practices that can engender new affectivities with science and education.). Zembylas (2016) and Alsop (2016) offer various musings and possibilities for science education and science education research that draw on the 'affective turn' (Clough, 2008) from within cultural studies of science.

Stepping out with care

Stepping into the STS literature with care compels us to step *out* of the discussion with care. We are reminded that 'critical care' is less concerned with a form of critique that is 'disapproving or judgmental' and more with a form of doing 'that is cautious, thoughtful and considered' (Martin et al. 2015, p. 12). Yet, this paper hinges on, perhaps, forms of harsh critique of fields of science and technology. We agree with Levinson (2018) and Sjostrom et al. (2018), amongst others, that there are relative merits to such portrayals given often de-politicized perspectives on science and technology within education. At the same time, we remain conscious that brushing on biopolitics in this essay could risk oversimplifying an otherwise complex, fluid and contested field (see Birch 2017). Hence, we invite further careful considerations into merits, challenges and vehicles for bringing such insights of STS into science education contexts.

Though we are committed to views of technoscience and education presented in this paper, we wonder how such views could be pedagogically enacted through 'slow' ontologies (Wallace 2018), which may disrupt 'strong' (Biesta 2015) approaches to education that seem to prioritize speed, efficiency and outcomes. As mentioned earlier, perhaps such pedagogical considerations could further take place in dialogic interactions between researchers, teachers and students, relative to specific contexts (echoing Torres-Olave and Bravo's multi-levelled dialogue). In that sense, we resist a grandiose one formula approach for articulating STS concepts within science education and propose that there might be merits in experimenting with new pedagogical approaches that won't delimit in advance what is 'science' nor assume students'/teachers' 'abilities' to engage with insights from this literature. This, is, of course, easier said than done. We can't pretend that reading through this literature was a simple and straightforward task. At various times, we struggled with 'abstractness' and complexity of notions, anticipating similar reactions from science teachers and students and ensuing resistance to such views. After all, this could be a risky undertaking for science education. Yet, we remain hopeful and comforted that, with risks come

'important *pleasures* through assuming subversive positions of knowing' (Zembylas 2007, p. 334, our emphasis) and being with science, technology and education.

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