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ORIGINAL PAPER

Rising against a gathering storm: a biopolitical analysis of citizenship in STEM policy

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Abstract Science, technology, engineering and mathematics (STEM) is a form of education seen by many governments and educators as a preparation of the types of students needed for the future. STEM education is being developed in many countries without the support of official policy, such as is the case in Canada. In the United States, the National Science Foundation (NSF), and a private non-profit organisation, Achieve Inc.™, have been enlisted to develop policy to guide the development on STEM nationally. Due to its influence in global politics and economy, many countries, including Canada, are interested in how the United States is preparing its citizens for the future through STEM education. In this paper we present a critical discourse analysis on STEM policy from the United States as a basis to discuss: biopolitics in science education; notions of citizenship in contemporary school education and science education; and citizenship and STEM education.

Keywords Biopolitics · Citizenship · Critical Discourse Analysis · Discourse · Next Generation Science Standards · Education Policy · STEM

A recent symposium at our university titled, "The STEM Movement: Golden Opportunity or Trojan Horse?" (https://www.youtube.com/watch?v=GNpAtQeiRWs&feature=youtu.be) resulted in discussion imbued with a polarizing tension. STEM is a form of education that integrates science with mathematics, engineering and technology. A rationale for STEM is that its relevant disciplines are naturally complimentary, and engineering and technology can provide the practical applications that will make science and math more

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meaningful for students, thus improving learning and retention in these fields (Achieve 2013a). A different rationale, however, appears to influence much current STEM reform; that is, according to many advocates of STEM (e g. Achieve 2013a; NAS 2007), there is increasing need to identify and train STEM workers so countries can remain competitive in the global economy which is becoming increasing reliant on innovations and products developed in and by STEM fields. Tension during the symposium was a result of adherence to these differing beliefs about the *politics* underpinning STEM education.

Debates over the politics of science education have been ongoing for nearly 40 years (Pedretti and Nazir 2011), and were greatly influenced by the "science wars" of the 1990's. During this time, postmodern scholars, such as Michel Foucault (1972) and Jerome Ravetz (1979), challenged a dominant idealism based on 'objectivity' and 'knowledge for knowledges' sake'. This is a depoliticised and perhaps naïve view of science, but one that has been propagated in science education for decades (Aikenhead and Ogawa 2007). In contrast, reforms such as Socio Scientific Issues (SSIs) in the USA and Science, Technology Society and Environments (STSE), in Canada, include beliefs that science is inherently political, because science is both a product and producer of cultural and social values and biases, which creates connections between science, society and citizenship that students can engage with. Like several of the panelists in the symposium, many advocates of STEM appear curiously disinterested in emphasizing its political nature, and many scholars (e.g., Gough 2015) have become critical of these silences, and question the political foundations of STEM education.

STEM education is being developed in many countries without the support of official policy, such as is the case in Canada. In the United States, the National Science Foundation (NSF), and a private non-profit organisation, Achieve Inc.™, have been enlisted to develop policy to guide the development on STEM nationally. Due to its influence in global politics and economy, many countries, including Canada, are interested in how the United States is preparing its citizens for the future through STEM education. In this paper we present a critical discourse analysis on STEM policy from the United States as a basis to discuss: biopolitics in science education; notions of citizenship in contemporary school education and science education; and citizenship and STEM education.

Biopolitics in science education

Educational policy can be seen to be a mechanism (Ball 2008) meant to govern into existence subjectivities, knowledges, and practices in citizens; what Foucault has termed a *biopolitics* (Foucault 2003), meant to produce particular 'types' of citizens required for certain intended forms of society. STEM educational policy can be seen as a way to manage school education to produce the human life needed to perpetuate particular biopolitical intents, such as developing the economy, rather than orienting students' attention and action toward meaningful social problems, such as consumption of the products of science and technology.

The dominant values and practices embedded in contemporary education policy appears to stem from *neoliberal* economic restructuring that began in the late 1970s in the UK and United States (Grimaldi 2012). In the neoliberal view, school education is a site of both individual and social economic investment from which students become potential human capital needed for economic systems in a competitive global market (Hay and Kapitzke 2009). Neoliberal intensification of capitalism has resulted in distillation of knowledge and skills most conducive to economic growth and production, at the expense of those needed

for democratic social participation (Klein 2007). To drive economic growth in late modernity, economic actors see school education as one of the mechanisms to cultivate citizen subjectivities that will perpetuate neoliberal economic systems (Pierce 2013).

One of the first sustained accounts of purposive management of human life occurred in Michel Foucault's 1975–76 lectures, *Society Must Be Defended*, in which he termed this perspective *biopolitics* (2003). An object of biopolitical analysis is how power is used to control and regulate populations (Hardt and Negri 2000). What biopolitics therefore generally means in Foucault's (2003) work is a type of politics that "deals… with the population as political problem, as a problem that is at once scientific and political, as a biological problem, as power's problem" (245). Biopolitics includes not only manipulation/control of human life, but also other life forms, including their components, such as DNA (Pierce 2013).

Language and policy that problematises citizenship has steadily increased since WWII, and is evident in policy documents such as No Child Left Behind and Rising Above the Gathering Storm (RAGS), on which STEM education in the USA is based. These documents construe a perceived national education deficiency as an "American" population problem that can be addressed through government and private sector interventions into schooling, institutional management, and other forms of government (Pierce 2013). Policy like this, according to Foucault, works to regulate populations through development of discourses and other forms of governmentality that empower certain qualities seen as useful or valuable in a population, combined with technologies of control, such as *performance expectations* (which is, interestingly, the categorical name of the student outcomes in the recent United States national STEM science standards) built into school standards and curricula. These expectations may therefore be seen as the mechanisms that allow biopower to operate, a "field of action that compels the individual to act by facilitating an internalization (or subjectification) of rationalities or "regimes of truth" that emanate from legal, health, or educational apparatuses of the state, for instance" (Pierce 2013, p. 13).

Modern global economic realities stretch ideas of governmentality from the national to the supranational, so that biopower operates through broader gloablised networks in order to influence creation of what Michael Hardt and Antonio Negri (2000) have termed *immaterial labour*; a form of human capital represented in certain skills, behaviours, literacies and habits that are foundational to a citizen optimised for neoliberal economics. Development of STEM policy and standards raises questions about how they may govern, or act as mechanisms of control, working towards the constitution of subjectivities, values and attitudes of *citizens* that are beneficial to producing the economic rationalism STEM prioritises.

Notions of citizenship

Citizenship has been a contested notion. Marshall (1998) frames citizenship as a nationally bounded set of universal legal and social rights and duties evolving out of the emerging historical and socioeconomic developments of post-war Keynesian states. Yet, this has been debated and critiqued for failing to account for how categories of class, race, gender, and sexuality have historically shaped claims to citizenship across Western democratic states. As Turner (2001) suggests, a citizen within Marshall's progressive narrative is imagined largely as a *passive* recipient of rights rather than as an *active* political subject.

Jacques Rancière provides an intriguing alternative conception of citizenship that aims toward a more just society (Means 2011). In Ranciére's view, citizenship in a democracy is an act of politics, which is itself an act of equality. In other words, citizenship is a participative, socially-constructed and dynamic subjectivity, rather than conferred status, ideally in which individuals are able to making decisions on, and challenge, the structures of society. This is a turn from typical views of citizen participation, which are based on inequality, or unequal equivalences between different levels of speech, knowledge and consciousness (Means 2011). Such views, according to Ranciére (2001), suppress politics through consensus: the legal codes and given systems of value and perception that demarcate who counts, where, how and why. Hence, authority, or what Ranciére terms 'the police,' represent the Platonic tradition of defining and maintaining the borders of 'the proper': the distribution of formal qualifications that delineate to each their particular role or place in society. Ranciére's philosophy for citizenship is different because it begins first by verifying the fundamental capacity of all to think, speak and act as equals.

Slavoj Žižek adds to this conception of citizenship (Žižek 2000, 2004) by claiming that democracy exists when subjects are able to participate in practices—material, artistic, intellectual, and linguistic—that challenge the 'place' assigned to them and in turn have this challenge verified by others. Citizenship can be seen to be a practice of disagreement and social recreation that reconfigures the social structures that contain it. For Ranciére, contemporary citizenship is largely a category operative within existing social structures, laws and subjectivities that define who each of us are in society, yet, his radical conception is suggestive of a kind of "ill-mannered" or "improper" form of citizenship that challenges these structures. According to Panagia (2009), "Ranciére's democratic citizen is not one who passively absorbs that which is assigned to her. She is, rather, the one who actively disrupts this referential operation by taking part in something to which she has no right. The democratic citizen is the agent of this improper part-taking" (p. 303).

Globalization has had recent influences on notions of citizenship (Isin and Turner 2002). Global transfers of capital, information, culture, technology and labour among urban, regional and transnational economic and ecological systems have replaced the pertinence of the nation-state as the sole authority and metric of citizenship and democracy. Transnational processes often appear to have shaped contemporary citizenship, which may be viewed as a more cosmopolitan practice (Hoffman 2004), while 'new social movements' and demands for 'group differentiated rights' and 'social recognition' (Taylor and Gutman 1994) have replaced the nation as a category of advocacy. Political activism for oppressed and marginalised groups have drawn attention to and critical reflection on citizenship as both a political practice and as a multidimensional site of cultural struggle.

Concurrent with these changes, there appear to be decreases in more traditional forms of democratic participation and citizenship. Bauman (2001), Brown (2005) and Giroux (2008) have analyzed the 'hollowing out' of civic life and subsequent colonization of citizenship by neoliberal market-based rationalities and practices. These rationalities and practices include individual strategization among various social, political and economic options, instead of striving with others to alter or organize these options to benefit the whole. A fully realized neoliberal citizenry would be the opposite of public minded; indeed, it would barely exist as public (Brown 2005). Neoliberalism works toward constituting citizenship as a consumer-practice, by individualizing politics that reduce race and class struggle to concerns over personal risk management, lifestyle = identity distinctions, commodified 'choices' and an unreflective multicultural emphasis on 'tolerating' the Other.

Citizenship and science/STEM education

Citizenship, whether stated explicitly or implicitly, has been a central goal of democratic school education, and the most common way values, attitudes and responsibilities associated with citizenship have been instilled in students (Heater 2004). Yet, school may present problems for the development of democratic principles; inequalities among teachers, curriculum and students are seen as a necessary undemocratic arrangement. The teacher (and curriculum) are positioned as the authority, or police, which provide the official knowledge, to which students are expected to align and acquire, passively, rather than democratically engaging with and actively constructing themselves. Such arrangements appear to be in direct conflict with notions of citizenship advocated by, for example, Ranciére (Means 2011).

Science education has struggled with issues of citizenship for decades—as the sociopolitical absences in past science curricula have reduced the space in science education necessary to develop the democratic orientations conducive to a citizenry that sees science as something they might utilize in the solution to community-based problems (Bencze 2008). There exists a strong emphasis in science education reform pertaining to citizenship that advocates for uses of science in ways that are relevant to students' lives and transformative to their communities (Mueller, Tippins and Bryan 2012). A common view of what democratic citizenship in science education might look like is one in which students, teachers and communities work together to use science to understand and address community problems, as opposed to inaction or passivity that often characterizes what it means to teach or learn science (Calabrese-Barton 2012).

Science education faces ethical and moral questions of whether to teach students for forms of science competency that prioritise employment after the completion of school, or whether this purpose should be secondary to engaging them in more active and participatory community grounded science typical of calls for social justice and citizenship (Calabrese-Barton 2012). A conservative element in science education, who cling to conceptions of science as culture and value free, may question why the socio-political considerations associated with citizenship need to be a part of school science at all (Mueller et al. 2012). Yet, there are compelling reasons to include these considerations. Kincheloe, Steinberg and Tippins (1992) emphasize that teachers, students and parents come to view the "community as a mini-laboratory for democratic participation" (p. 223). The ability to understand and use science is increasingly an everyday part of life for the average citizen. Arguments abound for student use of science to address social problems connected to science and technology (Bencze and Carter 2011). This stands in stark contrast to most contemporary practice of science, which is primarily conducted by scientists, and is aimed at specific, often economic, ends. Scientific knowledge constructed in professional research, however, may not consider the common good, and in fact, may perpetuate extant patterns of social class hierarchy (Campbell and Morgan 2005). This begs the question, 'To whom does science belong?' Sandra Harding (1991) voiced, long ago, feminist concerns regarding who science and knowledge are controlled by and for whom they benefit. Unfortunately, participative forms of science that prepare students for democratic citizenship appear to be relatively non-existent in schools, as student participation (i.e., caring for a community) is tightly mediated by those already with authority—those who set up the questions, the tools and the resources for participation (Calabrese-Barton 2012). This cements the neoliberal goals of scientific enterprises, rather than democratic citizenship goals (Calabrese-Barton 2012).

There remain questions about whether democratic citizenship can be learned in school science. As Weinstein (2012) has expressed, citizen science is unlikely to happen in schools—since schools are fundamentally undemocratic places. Science conducted in communities is difficult to enact in schools that are have sought out *placelessness* as a defining characteristic. In schools today, teachers and students are rarely asked to identify with place (local environment/community) as a part of teaching and learning science. Calbrese-Barton (2012), among others, notes that place ought to serve as context for, subject of, and driving relationship framing the doing of science. A push away from place has been the hallmark of reform over the past decade (Calbrese-Barton 2012). A dominant focus on standardization by testing acquisition of abstracted, rather than local, knowledge (Gruenewald and Smith 2007) has manifested in decontextualised standards and curricula that can be implemented anywhere, conferring a more universal form of control (Ball 2008). These features of contemporary science education draw it ever farther from notions of democracy that may allow spontaneous acts of equality in a type of citizenship participation articulated by Ranciére.

Despite the seemingly overwhelming chorus of positive-toned voices advocating for STEM education, there are significant critiques relevant to educating for citizenship. Clayton Pierce (2013), for example, cogently describes the potentially oppressive nature of STEM education in the USA. One of the questions implicit in his work is, what kinds of citizen or citizen subjectivities does STEM education intend to constitute to meet the economic ends driving these reforms? Other literature (e.g., Gough 2015) suggests such perspectives are lacking in STEM policy, raising questions about the nature of the inscribed citizenship education, and the very citizen subjectivities STEM policy supports.

One of the most influential sets of STEM policy of recent years is the Next Generation Science Standards (NGSS). The NGSS are a set of grade 1–12 national science standards designed to inculcate globally competitive STEM literacy in students from the USE that will be conducive to college study and careers in STEM fields. The NGSS are the result of a public–private partnership between economic and political leaders and educational consultants known as Achieve Inc. Led by Craig Barrett, former CEO of Intel Corporation, and Mark Grier, vice chairman of Prudential Financial. Achieve's contributors include global corporate and philanthropic elites, such as the Bill and Melinda Gates Foundation (BMGF), Chevron, AT&T, Boeing, Microsoft, and IBM. According to Achieve, it was "created by the nation's governors and business leaders, and is a bipartisan, non-profit organization that helps states raise academic standards, improve assessments and strengthen accountability to prepare all young people for postsecondary education, careers and *citizenship*" (Achieve 2012). Although the NGSS does not state citizenship education as an explicit component of the standards, its rich text base allows for discursive understanding of its biopolitics, which validates certain forms of citizenship. This paper evaluates discourse in STEM policy from the United States to evaluate how it constitutes citizenship through discursive features such as: how it controls what students learn; what knowledge is included and excluded, and; what human qualities are prioritised.

Methods

We conducted a Critical Discourse Analysis (CDA) of STEM policy in this study. Because policy is textually rich, it can be thought to contain discourse or discursive formations that can be identified, analysed and criticised (Chiappetta and Fillman 2007). Our conception of

discourse is based on Foucault's, first appearing in *Archaeology of Knowledge* (1972) and developed further in his lecture on 'the order of discourse' (Foucault 1980). Foucault's European-philosophical articulation of discourse is frequently associated with human action or practice, as seen in his frequently quoted statement that discourses are "practices that systematically form the objects of which they speak" (1972, p 49). Discourse can be broadly described as sets of practices and/or knowledge that construct reality and provide a shared way of "producing meaning, forming subjects and regulating conduct within particular societies and institutions, at particular historical times" (MacLure 2003, p. 175). Thus, STEM policy documents includes both potential and actual discourse that might be said to constitute both the possibilities and the limitations of what can be said, done or known by teachers and, in effect, students, in school science based on these standards.

Critical discourse analysis involves the study of written texts and spoken words to reveal how power, dominance, inequality and bias are initiated, maintained, reproduced, and transformed discursively within specific social, economic, political, and historical contexts (van Dijk 1988). As critical analysts, we want to illuminate ways in which powerful social practices, such as those representative of neoliberalism and biopolitics, are embedded in the construction of STEM policy and education, and which thereby perpetrate these same practices and corresponding power.

In CDA, Huckin (1997) recommends first looking at the text as a whole to identify the genre of the text and the perspectives presented, called *framing*. Afterwards, we employed more minute levels of analysis derived from CDA methods described by Gee (2011) and Fairclough (2003), which are described, with examples from 'front matter' text in the NGSS, in Table 1.

We consulted the literature on neoliberal and STEM education reform, to identify themes and categories, which were then negotiated between us until consensus was reached (Wasser and Bresler 1996). Themes that became the basis of critical discourse analysis were based on stages of biopolitical development (Foucault 2003), consisting of: (i) problematising citizenship; (ii) constituting citizenship, and; (iii) developing citizenship. Within developing citizenship, we discuss several sub-themes related to the NGSS, including: (i) performance; (ii) student qualities, and: (iii) sociopolitical representation.

Findings

Although STEM policy is diverse, it has features characteristic of biopolitical discourse, such as problematising a social phenomenon (problematising citizenship), describing solutions to the problem (constituting citizenship), and developing solutions (developing citizenship).

Problematising Citizenship

One of the first steps in biopolitical development is to problematize some aspect of society (Foucault 2003). Great effort has been made by STEM policy makers in the USA to disseminate discourse that problematises citizenship. Policy attempts to generate support for an issue by creating a sense of threat and fear among the public (Beck 1999). These features are apparent in the zeitgeist of the National Academy of Science's (NAS) *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future* (RAGS), on which national STEM standards are based, which claims "the inadequacies of

Table 1 CDA of STEM policy in the USA Adapted from Hoeg and Benzce 2017)

CDA Methods	NGSS Statement	Interpretation
Unspoken/naïve assumptions—this strategy attempts to articulate what the text is saying without actually saying it. Such text includes statements about what is real (ontological), statements of knowledge establishing what exists, propositional assumptions (what's going to happen), and value laden assumptions Are arguments for some things assumed and for others, not assumed?	To remain economically competitive, countries are pressed to substantially increase the number of students who can put knowledge to use in the service of new frontiers—discovering new knowledge, solving challenging problems, and generating innovations (Achieve 2013b, p. 1)	The "naïve" assumption is that more students (i.e. citizens) are needed to discover new knowledge, solve problems and generate innovations, or, for STEM jobs. Yet, recent data suggests there are in fact already too many STEM graduates in the USA competing for these jobs (Anft 2013)
Meaning conveyed by words—in this strategy, each statement is viewed only through the meaning conveyed by the words themselves, rather than through the historical and sociocultural frames that give the statement other meanings. This helps to identify assumptions and what is taken for granted	The real innovation in the NGSS is the *requirement* that students are *required* to operate at the intersection of practice, content, and connection. *Performance Expectations* are the right way to integrate the three dimensions (Achieve 2013a, p. 6)	The word "requirement" and "required" removes the potential for teachers and students to enact the standards. This, limitation of democratic practice reinforces subjugation to authority and restricts the development of aptitudes and orientations conducive to democratic citizenship (Giroux 2008)
Internal relations—involves the semantic relation between clauses, words, sentences, grammatical relations (subordination of one thing to another), and the lexical relations between terms (the occurrence of one word with another (e.g. engineering and innovation)	Engineering is a field that is critical to innovation, and exposure to engineering activities (e.g., robotics and invention competitions) can spark interest in the study of STEM or future careers (Achieve 2013c, p. 1)	There is an international relationship created in this statement between engineering and innovation, and engineering and interest, making it appear that innovation and interest are dependent on engineering experiences in STEM education, and that these are important qualities for students (citizens) to have
Questioning how language contributes to a particular effect or meaning—how would a statement's meaning or connotation change if the statement were re-written grammatically. How does the way it is written now contribute to a particular effect/meaning?	In sum, today's new reality demands that science and engineering become accessible to the many, not the few. And because the needed proficiencies are acquired over time, students must experience how science and engineering are conducted in the workplace throughout their K-12 schooling (Achieve 2013b, p. 2)	A "new reality" and its "demands" are absolute and unquestionable, leaving no space for other interpretations about the truth of this reality or the demands it places on societies. The statement also presents "science and engineering" as an unchangeable commodity in which students (and citizens) must personally invest into access these disciplines. The effect becomes clearer when considering the opposite word sequence, 'students become accessible by science and engineering', which assumes science and engineering must change/invest in teachers and students so they can obtain and use them

Table 1 continued

CDA Methods	NGSS Statement	Interpretation
Privileged ways of knowing and speaking—how do the statements privilege one system of signs and knowledge over another? What kinds of knowing/speaking are privileged? What kinds of knowing/speaking are marginalised and/or absent?	Science is at the heart of the United States' ability to continue to innovate, lead, and create the jobs of the future. All students—whether they become technicians in a hospital, workers in a high tech manufacturing facility, or Ph.D. researchers—must have a solid K–12 science education (Achieve 2013a, p. 1).	Ways of speaking about education as a vehicle for economic development (jobs), which is typically neoliberal, is dominant and privileged. Ways of speaking about education as a vehicle for community development, social equity and social justice, important components for a functioning democracy, are marginalized in its absence

our system of research and education pose a greater threat to U.S. national security over the next quarter century than any potential conventional war that we might imagine" (NAS 2007, p. 25). Here there are semantic relations between inadequate and education, and threat and security, that convey a meaning that inadequate education in the US is a threat to national security. Implicit is this statement is that there are certain types of educated students/citizens needed to ensure national security, yet they are lacking in the USA. The use of the word 'security' activates an emotional response (Fairclough 2003) of anxiety and fear, connecting these emotions to the lack of an adequately prepared citizenry. Policy statements such as this trigger negative emotional responses to the "problem" so that there will be minimal resistance to, and ideally, support, for solutions to the problem.

The inadequacies of the citizenry in the USA is further articulated by the President's Council of Advisors on Science and Technology (2012), who claim "1 million more STEM professionals than the U.S. will produce at the current rate are needed over the next decade if the country is to retain its historical pre-eminence in science and technology."(p. 1). The underlying assumption is that more citizens trained for STEM jobs are needed to address the threat to the US "historical pre-eminance", which implies a superior society and standard of living. The statement further assumes that a superior form of citizenship is sustained through national dominance in science and technology. Again, fear and anxiety is alleviated in a solution—to maintain superiority in science and technology fields, by preparing more STEM professionals.

These policy statements attempt to mobilize the public by creating positive attitudes toward the solutions proposed by those disseminating STEM discourse. Such strategies can be seen to prioritise and privilege citizen subjectivity that will respond positively, or at least provide little resistance to, STEM initiatives. These policies, however, are silent on much of the biopolitics that are foundational to the construction of such policy.

Constituting citizenship

According to Foucault (2003), subsequent steps in biopolitical development involve constituting the problem by defining and disseminating it relative to target populations, along with well-defined and contextualised solutions. STEM policy constitutes citizenship by defining citizen qualities needed to ensure security in this unforeseen and threatening future, and positions education as a solution. The initial fragments of this discourse can be seen RAGS, which identifies features of science literacy it claims is needed among citizens to address the identified problem.

> Without basic scientific literacy, adults cannot participate effectively in a world increasingly shaped by science and technology. Without a flourishing scientific and engineering community, young people are not motivated to dream of "what can be," and they will have no motivation to become the next generation of scientists and engineers who can address persistent national problems, including national and homeland security, healthcare, the provision of energy, the preservation of the environment, and the growth of the economy, including the creation of jobs. (NAS 2007, p. 112)

The discourse in this statement connects scientific literacy with effective citizenship (participate effectively). The dominant way of speaking in this discourse is that a scientifically literate citizenship represents 'progress', evident in the use of phrases such as "next generation" (of scientists and engineers) (Brown 2005). Science and engineering are constituted as essential for a motivated youth who innovate (dream of what can be), which RAGS claims are required to produce the types of citizens that will be involved in solving 'national problems'; this phrase implies the nation-state as the site of citizenship. In neoliberal discourse, however, these so called national problems, including 'homeland security' (NAS 2007), healthcare, the creation of jobs, and growth of the economy, are seen as solvable through private sector intervention and governance (Giroux 2008). In actuality, being a productive citizen under neoliberal guise means individually contributing to the advancement and growth of corporations, who are figured as the rising tide that will raise all ships, either through individuated consumer based practices, or labour contributions to science and technology that enable corporate production (Pierce 2013). By not including other citizenship roles (e.g., community participation and advocacy) the underlying assumption is that certain roles and types of citizens (consumers, scientifically literate, working in science and technology related fields) are more effective in addressing the problems that threaten the nation, particularly a slowing economy. RAGS also identifies the institutional mechanisms that can contribute to the development of this type of citizen, stating:

> The US system of public education must lay the foundation for developing a workforce that is literate in mathematics and science, among other subjects. It is the creative intellectual energy of our workforce that will drive successful innovation and create jobs for all citizens. (NAS 2007, p. 112)

The discourse here clearly links education with the production of the types of citizens claimed to be needed to solve contemporary social problems in the USA. Qualities of innovation and creativity are discursively inserted into the fabric of citizen subjectivities needed to achieve the social reality desired by those producing this discourse. These qualities, it is stated, are needed in workers to advance an economy (create jobs for all citizens) that will benefit the entire USA.

Policy creators assert STEM education is beneficial to even the 96% of citizens who will not attain a science and technology job (Achieve 2013a, b, c, d). For example, the President's Council on Science and Technology (PCAST), in the USA, claim, "It (STEM education) will strengthen our democracy by preparing *all* citizens to make *informed choices*" (Emphasis added) (PCAST 2012, p. 1). While citizens making informed choices should be positive features of a democracy, neoliberal discourse constitutes choice as a function of consumerism and individualism, such as in making individual choices about what products to purchase (Klein 2007). Indeed, this appears to be, at least in part, the

meaning of this discourse, as text latter in the document further defines the role of STEM in the average citizen's life:

> The products of science, technology, engineering, and mathematics play a substantial and growing role in the lives of all Americans. A democratic society in which large numbers of people are unfamiliar or uncomfortable with scientific and technological advances faces a great economic disadvantage in globalized competition (PCAST 2012, p. 1)

The connection between citizen knowledge of the products of STEM and the economy is made here, suggesting the writers of this policy see STEM literacy as functioning to provide attitudes and knowledge among citizens conducive to the consumption of STEM products that will grow the economy. To achieve this, students educated in STEM programs are schooled to endorse, rather than question, those choices and practices that drive neoliberal economic systems (Pierce 2013). Even students who do not major in science and technology programs, "will form a different breed of high school graduates who view science as an 'effective method of inquiry' and who will serve as productive 21st-century citizens to create a sustainable planet" (Krajcick and Merritt 2012). Implicit in this discourse is the assumption that 'science' is 'effective', but disregards questions about who's science (Harding 1991), or what is meant by 'effective' (Means 2011). Again, a way of speaking about STEM education as a form of progress (productive) disregards other meanings of progress untied to attaining a (science and technology related) job, and other forms of citizenship that are not oriented toward this end. Implicit in this discourse is that new types of citizens with qualities that are conducive to business goals, or, at the very least, those who won't interfere with this process, must be governed into existence, and the technology of governance must come from STEM education.

Developing citizenship

STEM policy and discourse in the USA has manifested in, among other products, the NGSS. The NGSS can be seen as a "technology" (Foucault 2003), meant to develop a citizenship conducive to the biopolitical goals of the corporate and governmental leaders who developed them (Hoeg and Bencze 2017). In this section, we will discuss the discursive mechanisms in the NGSS that maximise the production of types of students its creators envision as necessary for present and future society.

Performance in the NGSS

If the NGSS are to develop citizen subjectivities prioritised for future science and technology based economies, they must be implemented as its developers intended (Achieve 2013a). The policy communities involved with the NGSS point out that to achieve this, highly specific and demonstrable standards are needed to measure student achievement and ensure students are receiving the prescribed education (Achieve 2013b). In other words, these communities believe standards have to be specific so that teachers know exactly what and how to teach students, which works to ensure the intended learning is achieved. Defined sets of practices are critical to neoliberal systems of authority and accountability and are features of *performativity*. Performativity, according to Stephen Ball (2000), is:

> A technology, a culture, and a mode of regulation, that employs judgements, comparisons and displays as means of control, attrition and change. The performances (of individual subjects or organisations) serve as measures of productivity or output, or displays of 'quality', or 'moments' of promotion or inspection. (p. 2)

Taken literally, 'performance' in everyday usage can mean; "the act of doing a job, an activity, etc. (Merriam Webster 2013), or "the accomplishment of a given task measured against preset known standards of accuracy, completeness, cost, and speed" (Business Dictionary n.d.). These meanings convey an idea that there is a right way to do an activity, and an individual's mastery of its enactment is demonstrated in the quality of her/his performance. The creators of the NGSS communicate what they view as a necessary performance through *performance expectations*, suggesting an intention to control the ways students must learn and teachers must teach. Indeed, the writers of the NGSS claim:

> The real innovation in the NGSS is the *requirement* that students are *required* to operate at the intersection of practice, content, and connection. *Performance Expectations* are the right way to integrate the three dimensions" (emphases added). (Achieve 2013a, p. 6)

These requirements are a way to maximise the probability that the knowledge, skills and attitudes valued by the developers of the NGSS, are taught. For example, the high school Life Science performance expectation HS LS1-1, states: "Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through specialised cells". This standard is performative because it requires that students engage in a specific practice, to *provide an explanation,* that DNA constructs protein and protein carries out the essential functions of life. The requirement that students' practice validates specific, pre-constructed knowledge maximises its performativity, further constraining the possibilities for divergent student learning outcomes. Although few would argue against the value of being able to explain the functions of DNA, an emphasis on programmed constructions may lead to the production of knowledge consumers (Wood 1998), reproducing aptitudes and expectations necessary for being 'informed consumers' in neoliberal economies (PCAST 2012). Less performative standards might allow student to *participate* in the enactment of the standards through inquiries about how genetic knowledge is utilized in, for example, corporate controlled bioengineering laboratories, leading to student debate about the non-democratic use of this knowledge, challenging authority, which, as Ranciére might argue, is more relevant to the practice of citizenship. In a previous study (Hoeg and Bencze 2017) we found that 59% of the Performance Expectations are highly performative, nearly 41% are moderately performative, and less than 1% were found to be non-performative. This substantiates the claims made by many authors (e g. Tonso and Weinstein 2012) that the NGSS are prescriptive, authoritative standards.

Along with this discursive field of student and teacher performance in the NGSS, are also the disciplinary technologies that measure, evaluate, and correct the pedagogy of teachers through tools such as value added metrics and merit pay (Dorey 2013). These, when connected to performance expectations, are likely to further railroad teacher practice toward those activities most effective in achieving the required performances outlined in the NGSS, limiting student participation in constructing knowledge and instead submitting to the 'police,' the authority of the teacher and the curriculum, stunting the development of citizenship orientations based on equity and democracy.

Citizen qualities in the NGSS

One might argue that the performativity in the NGSS is not new, and simply represents capitalist schooling rebranded. Yet, the biopolitics of its performativity is neoliberal in the way it attempts to develop certain qualities in students conducive to neoliberal society. For example, the NGSS' contains goals to develop aptitudes of *innovation* in students. Innovation is among the most ubiquitous terms found in neoliberal education reform policy, prioritised due to its perceived importance in creating new markets for economic growth (Means 2011). According to Apple (2004), neoliberalism "creates policies and practices that embody the enterprising and constantly strategizing entrepreneur… [as] the ideal citizen" (p. 196). The application of seemingly unlimited creative capacities of individuals to the structured uncertainty of modern, globalised, social life promises the possibility and anticipation of improved performance (Hays and Kapitzke 2009), making the creative self as one that permanently adds value to the market. In neoliberal guise, innovation and creativity are associated with the development and dissemination of new markets for consumer consumption and corporate profit (Turunen and Rafferty 2013).

There is no question that innovation can be a positive outcome of education, and Bereiter and Scardamalia (2008) connect the idea of creativity to innovation, claiming that education that develops innovation contains provisions for and allowance of 'outside-of-the-box' or counter paradigmatic perspectives, opportunities for student agency and flexibility of instruction, all features we would consider to be beneficial. The NGSS identifies engineering experiences as a primary site for the development of innovation, stating,

> Engineering is a field that is critical to innovation, and exposure to engineering activities (e.g., robotics and invention competitions) can spark interest in the study of STEM or future careers. (Achieve 2013c, p. 1)

There is an international relationship created in this statement between engineering and innovation, and engineering and interest, making it appear that innovation and interest are dependent on engineering experiences, and that these are important qualities for students (citizens) to have. An assumption underlying this discourse is that innovation can and should be purposely developed in students because it is a resource that is expected to fuel future economies (Pierce 2013).

The NGSS prioritises innovation and creativity through the incorporation of engineering standards, which "offer opportunities for 'innovation' and 'creativity' at the K-12 level" (Achieve 2013c, p. 5). These standards describe specific activity in which existing science knowledge is changed (develop; plan; refine; revise) or newly created (create; develop; model). Science and engineering practices are required in *every* performance expectation, supporting the importance of innovation and creativity to the creators of the NGSS. However, 94% (Hoeg and Bencze 2017) of the performance expectations articulate specific, non-participatory practices that *must* be performed while enacting these expectations. For example, the Performance Expectation HS-LS2-2: Ecosystem Interactions and Dynamics, states: "Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales". Within this expectation, students could use personal and community contexts to construct knowledge about local biodiversity and ecosystems. The requirement to use mathematical models, however, may be inaccessible to many students (Allen et al. 2013) and limits the ways this knowledge can be learned and expressed, prioritising quantitative representations of ecosystems. This restricts other ways knowledge of ecosystems might be demonstrated that may be more conducive to innovation than this

rather typical scientific representation. One can imagine students might use artwork, videos, or multi-media presentations to represent various knowledge of ecosystems, such as how industrial and corporate activity effects biodiversity in communities. Indeed, these practices may be more relevant to the education of citizens for democratic society.

The NGSS authors claim "All eight [science and engineering] practices are accessible at some level to young children; students' abilities to use the practices grow over time (Achieve 2013d, p. 2). Yet, requiring the construction of mathematical representations and other non-participatory math and engineering practices restrict student activity to that which conforms to the dominant paradigms and practices described by STEM policy makers, negating diverse perspectives and life experiences students bring with them to school that are necessary for creativity and innovation (Hayes and Kapitzke 2009). Ironically, this tight system of control that advocates for innovation and creativity, is at the same time prescriptive, containing little allowance for the flexible and student-constructed educational experiences needed to foster these qualities (Means 2011).

Sociopolitical representation in the NGSS

Key to citizenship science is the content that is included in curricula and standards (Alexiadou 2005). The addition of engineering, technology and math content to school science has narrowed the space available for science content, and caused dilemmas about what content is important (Tonso and Weinstein 2013). In addressing this dilemma, the NGSS states:

> *Not all content is equally worth learning* Some science concepts deserve the lion's share of instruction because they have explanatory or predictive power or provide a framework that facilitates learning and applying new knowledge (Emphasis added). (Achieve 2013c, p. 3)

The focus on content and concepts in this statement demonstrates Achieve's prioritisation of acquiring known knowledge products (Wood 1998), such as existing science knowledge and theory. Implicit in this is that their selection of knowledge and practices was based on particular values and beliefs about what students (citizens) need to know, and, essentially, what kinds of citizens they deem to be important. The prioritisation of certain content, however, evokes questions about what has been left out of the NGSS.

NOS, environmental topics, and Socio-scientific Issues (SSIs), are potentially effective citizenship science content because, ideally, they enable democratic forms of learning grounded in personal and community contexts (Bencze 2008). NOS describes practices of science and includes topics such as: how scientific research and inquiry is conducted; what is included as scientific knowledge; epistemology of science, and; cultures of science (Lederman et al. 2002). Environmental and SSIs education requires space in curricula for students to explore environmental and social issues related to science, technology and society, such as those related to food and drug production, requiring citizen decision making and advocacy (Zeildler et al. 2005). Within these topics, students may *produce* science knowledge related to local communities, and develop political stances leading to action, making them ideal for democratic citizenship education. Environmental education and SSIs, however, occurs in only 8 and 5%, respectively, in highly performative performance expectations of the NGSS (Hoeg and Bencze 2017). Omission and/or prescription of this content may simply act to inculcate in students a view that solving SSIs and environmental problems is a theoretical outcome of science and other impositions of

authority, rather than to see science as a vehicle for democratic participation in local decision making and problem solving (Bencze 2008; Skogen 2010).

Conclusion and Implications

The discourse related to citizenship embedded in much STEM policy from the United States appears to prioritise augmentation of STEM workforce numbers and economic gains for corporate networks driving science reform, rather than developing democratically grounded citizenship. Another way to frame such policy is that of a biopolitical technology meant to govern into existence priorities and values of corporations (Pierce 2013). That these priorities and values are openly acknowledged in the NGSS speaks to the extent to which economic values and practices have come to define what citizenship means in contemporary, neoliberally-derived, science education.

Much STEM policy appears to be characteristic of neo-liberal mechanisms of control. Such policy maximises the likelihood that the economic discourse valued by its developers is practised by teachers and learned by students. Science education policy discourse such as this plays a critical role in 'fabricating and mobilizing' science educators by translating apparent anxieties and concerns about global uncertainty into a single narrative of necessary school science change and adaptation (Nicoll and Edwards 2004). It is premised on the notion that students who invest more in STEM knowledge and skill acquisition will be rewarded by superior future earnings, thus enjoying greater amounts of democratic freedoms. The sociopolitical silences apparent in much STEM policy (Gough 2015) make it seem unlikely students will engage in criticism of STEM processes and practices that support economic growth, and instead will orient students to support them. This neoliberal conception of citizenship remains silent on ways students and teachers may participate in the construction of their own education, taking it ever farther from forms of participative education that model democratic citizenship (Te Riele 2006). Indeed, STEM standards and curricula, such as the NGSS, appears to represent a magnification of authority that tighten control of teaching and learning so that types of citizens valued by the corporate and political actors who create STEM policy are prioritised (Means 2011). Issues of accessibility and inequity inherent in such authoritative systems reward already privileged individuals/groups, and have been connected to ever-widening gaps between the rich and poor in the USA (Campbell and Morgan 2005). This raises concern about the social justice of forms of STEM education that may further perpetuate this trend.

Our analysis identifies a theoretical outcome of STEM education, yet policy needs to be measured by results, not theoretical discourse or implicit intention. A considerable amount of research aimed at implementing STEM policy is presently occurring, evident in the abundance of papers presented on this topic at national and international education conferences (AERA 2015; NARST 2015). Research and development programs could potentially inform teaching practices and cultures that enable a more socially just enactment of STEM education than what we have described. More equitable and democratic interpretations of STEM policy are certainly possible since, even with its neoliberal foundation, it expresses laudable goals such as raising the standards of underachieving working-class and minority students, responsible citizenship, and engaging students in social problems related to science, goals that could be taken up by local school communities to develop citizenship science education. However, other seemingly well-intentioned neoliberal education reforms, such as NCLB, are not working, and have, for example, been

highly discriminatory towards the poor and people of colour, reproducing the advantage and social privilege these programs claim to alleviate (Hursh 2007). Instead, the implicit aims of such programs appear to both dismantle public education and develop uncritical, competitive, neoliberally aligned citizens (Leyva 2008; Boyles 2005).

A science education that values practice of science as essential parts of participatory democracy is, we suggest, more truly just than an orientation that positions it as a source of power for the select few and a resource for corporate economic development. STEM education, in our opinion, must provide space for students to participate in broad forms of science education that will enable them to expand its scope, innovate, construct new science knowledge, and see new ways science might be practised by citizens to address social issues connected to communities and the common good. Unfortunately, much STEM policy does not appear to represent such an education. Instead, the discursive oppression and exploitation of citizens implicit in the STEM policy evaluated here is a brazen betrayal of the espoused values associated with freedom in democratic Western societies.

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