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Toward a State-Critical STEM Education

Jamie E. Teeple
The Ohio State University

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Abstract

I seek to problematize the claim that STEM education simply passes as a “justified” educational reform discourse. I first review Rodger Bybee’s (2013) comprehensive case for STEM education. I then subject his case to philosophical and political critique via John Dewey (2012 [1916]), Andrew Hacker (2016), George Counts (1978 [1932]), Sheldon Wolin (2008), Wendy Brown (2015), and Nataly Chesky and Mark Wolfmeyer (2015). I conclude that Bybee’s proposal is ultimately illiberal and conducive to the maintenance of an oppressive status quo. I proceed by reviewing educational responses to the status quo, including those of Judith Suissa (2010), Jennifer Logue and Cris Mayo (2009), Abraham DeLeon (2006), Mark Wolfmeyer (2012), and finally, Nataly Chesky and Mark Wolfmeyer (2015). I conclude that Chesky and Wolfmeyer offer a promising framework for STEM education but suggest that it could further implement an approach that provides students with opportunities for learning explicitly about the status quo.

Keywords: STEM Education, American Imperialism, Neoliberalism



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Introduction

Alexandra Ossola (2014) has suggested that although STEM education has generated a lot of recent buzz, “in general its hype is justified because students simply need greater scientific and technological literacy than they did before to function in today’s society and economy” (Ossola, 2014). I seek to problematize the claim that STEM education simply passes as a “justified” educational reform discourse. I first review Rodger Bybee’s (2013) comprehensive case for STEM education. I then subject his case to philosophical and political critique via John Dewey (2012 [1916]), Andrew Hacker (2016), George Counts (1978 [1932]), Sheldon Wolin (2008), Wendy Brown (2015), and Nataly Chesky and Mark Wolfmeyer (2015). I conclude that Bybee’s proposal is ultimately illiberal and conducive to the maintenance of an oppressive status quo. I proceed by reviewing educational responses to the status quo, including those of Judith Suissa (2010), Jennifer Logue and Cris Mayo (2009), Abraham DeLeon (2006), Mark Wolfmeyer (2012), and finally, Nataly Chesky and Mark Wolfmeyer (2015). I conclude that Chesky and Wolfmeyer offer a promising framework for STEM education but suggest that it could further implement an approach that provides students with opportunities for learning explicitly about the status quo.

A Call to STEM Education

Rodger Bybee (2013) has proposed a nuanced appeal for STEM education. He offers *The Case for STEM Education: Challenges and Opportunities* as a guide for policymakers, administrators, academics, and educators to clarify what STEM education could mean and entail in future policy, programs, and practice, writing that, “One of the purposes of this book is to help individuals make sense of STEM education—in the context of their work—and move STEM from a slogan to a constructive innovation in American education” (Bybee, 2013, p. 2). What is notable about Bybee’s work, however, is that it does not endorse any explicit program for STEM education. Instead, he admits that STEM education itself is a nebulous term, offering coherence within context. His initial agnosticism toward the ineffability of STEM education gives way, however, to an abrupt commitment to specific aims to which he thinks education in general should nevertheless contribute: “(1) a STEM-literate society, (2) a general workforce with 21st-century competencies, and (3) an advanced research and development workforce focused on innovation” (p. x).

On one hand, Bybee thinks that STEM literacy must transcend an educational approach to the STEM disciplines that fails to recognize the realities of students’ lives. In short, STEM literacy must prepare students to confront the daily problems they will experience as citizens. He explains,

K-12 education should contribute to individuals’ life and work as citizens. Education in the STEM disciplines also should include the application of these knowledge, skills, and abilities to life situations in STEM-related categories such as health choices, environmental quality, and resource use. While understanding the concepts and processes of traditional disciplines certainly contributes to citizens’ intellectual growth, I argue that future citizens need educational experiences that transcend the traditional boundaries of science, technology, engineering, and mathematics disciplines. (pp. ix & x)

Resonating with the Deweyian notion that education should have an intimate relationship to students' lived experiences, he adds,

If we want students to learn how to apply knowledge, their education experiences must involve them in both learning the knowledge of STEM disciplines and reacting to situations that require them to apply that knowledge in contexts appropriate to their age and stage of development. (p. x)

He believes, therefore, that the cultivation of STEM literacy for everyone is a concrete purpose for STEM education, regardless of programmatic and conceptual variability.

On the other hand, he contends that there are other “challenges and opportunities” that STEM education can address through the cultivation of STEM literacy. More specifically, he identifies two overarching challenges for future citizens and workers: global economic competitiveness and national security, with the two being interrelated (pp. 101 & 102). He writes,

Now the United States must address the reform of STEM education, in this case because we are losing our competitive edge in the global economy. However, this era is very different from the Sputnik era. The competitors are greater in number—countries with developed economies, such as Canada, France, Germany, and Japan, and especially the fastest-growing economies, such as China and India. The primary goal is less clear and more complex: to prosper in a global economy and maintain national security. (pp. 101 & 102).

It is toward the fulfillment of these aims that his view of STEM education moves beyond the cultivation of the individual and her literacy (and her relationship to her community) and toward economic, national, and global pursuits.

But to meet these challenges, he argues that “the United States must address the reform of STEM education, in this case because we are losing our competitive edge in the global economy” (p. 101). Part and parcel of this reform for the purposes of economic competitiveness and national security is “a broader, more coordinated strategy for precollege education in science, technology, engineering, and mathematics (STEM),” which, “should include all the STEM disciplines and address the need for greater diversity in the STEM professions, a workforce with deep technical and personal skills, and a STEM-literate citizenry prepared to address the grand challenges of the 21st century” (p. 101).

Ultimately, Bybee envisions STEM literacy as advantaging the individual, society, and the United States for different reasons, including intellectual growth and economic opportunity for the individual, an influx of critical citizens for society, and economic competitiveness and national security for the country. Due to these advantages, he thus suggests that we move from STEM education as a mere slogan to STEM education as a reality, perhaps via a “goal-directed movement”: He pronounces,

The STEM community responded vigorously to produce the Sputnik-spurred education reforms of the 1960s. Likewise, the United States needs a bold new mission and strategy for improving education that includes the development of high-quality teachers, effective instruction, and curriculum materials with grand challenges of society at the center of study. (pp. 4 & 102)

Bybee thus appears to have made a balanced case for implementing STEM educational programs nationally. He seems to have carved out a place in the thinking about STEM education

for students' pursuit of interests, while also paying mind to economic and geopolitical concerns. But are there ultimately tensions between these two considerations? And are there reasons we should be critical of his insistence upon leveraging STEM education as a means for buttressing American power in this "Sputnik moment" (p. 30)?

STEM and the Status Quo

John Dewey (2012 [1916]) cautioned us against establishing education as a means to prescribed ends. He reasoned that instrumentalizing education essentially negated its capacity for developing rationality for present experience. In *Democracy and Education*, he wrote,

Since education is not a means to living, but is identical with the operation of living a life which is fruitful and inherently significant, the only ultimate value which can be set up is just the process of living itself. And this is not an end to which studies and activities are subordinate means; it is the whole of which they are ingredients. (Dewey, 2012, p. 255)

With respect to science education specifically, Dewey argued that it, too, should be undertaken as an intimate facet of lived experience, having written that, "All that we can be sure of educationally is that science should be taught so as to be an end in itself in the lives of students – something worth while [sic] on account of its own unique intrinsic contribution to the experience of life. Primarily it must have 'appreciation value.'" (p. 256).

He thus disavowed disciplinary hierarchy, warning that, "We cannot establish a hierarchy of values among studies. It is futile to attempt to arrange them in an order, beginning with one having least worth and going on to that of maximum value," and that, "In so far as any study has a unique or irreplaceable function in experience, in so far as it marks a characteristic enrichment of life, its worth is intrinsic or incomparable" (Dewey, 2012, pp. 254 & 255). He also held that science in general should be considered integral to the cultivation of experience, for it can

change men's idea of the nature and inherent possibilities of experience. By the same token, it changes the idea and the operation of reason. Instead of being something beyond experience, remote, aloof, concerned with a sublime region that has nothing to do with the experienced facets of life, it is found indigenous in experience: – the factor by which past experiences are purified and rendered into tools for discovery and advance. (p. 239)

Thus, in the Deweyian view, the very agglomeration of STEM education's disciplines into its sonorous and nominal acronym is artificial, unnecessary, and potentially detrimental to the enactment of education as an integral component for rational experience.

Dewey also criticized the instrumentalization of education as a means for economic ends, invoking education's complicity in the institutionalization of alienating labor practices. He implored,

the great majority of workers have no insight into the social aims of their pursuits and no direct personal interest in them. The results actually achieved are not the ends of their actions, but only of their employers. They do what they do, not freely and intelligently, but for the sake of the wage earned. It is this fact which makes the action illiberal, and which will make any education designed simply to give skill in such undertakings illiberal and immoral. The activity is not free

because not freely participated in. (p. 276)

Andrew Hacker (2016) has recently used a Deweyian approach to critique the putative “hegemony” of STEM education, arguing in *The Math Myth: And other STEM Delusions* that it is of touch with the needs and abilities of youth and even deleterious to future generations of students, workers, and citizens (Hacker, 2016, p. 11). He problematizes the dominant instrumentalization of STEM education as occupational preparation and derides the conceptualization of mathematics education as technical training in the Common Core State Standards, stating that, “The Common Core’s approach to both language and mathematics—science and social studies are to come later—embodies a particular conception of education, turning on the technical training and skills employers say they want and need” (pp. 117 & 118).

He ultimately characterizes our educational status quo as being caught between two ideological schools, the “Discovery” and “Discipline” Schools (p. 132). He explains that the Discovery School has its roots in the philosophy of Dewey, which “endures” in colleges of education (p. 138). Discovery approach advocates value collaboration over isolated individualism. They prefer student construction of knowledge and believe that this is the best way for students to learn. They also make the reasons for solving problems central to the very process of solving problems and seek to foster students as problem-solvers and effective collaborators. “The Discovery ideology,” he writes, “also sees each pupil as an inquiring intellect, an imaginative creator, an incipient artist” (p. 142). It also sees the teacher, on the other hand, as a guide rather than a sage.

The Discipline school, however, promotes the pursuit of the correct answer, a mathematics curriculum that serves as a gateway to little more than collegiate advancement, and national standards that do not address the needs or laud the diverse talents of our nation’s youth (pp. 132, 139, & 140). The approach is also contingent upon an ideology that eschews allusions to “the beauty of mathematics, its intellectual provenance, or its place in the natural universe” (p. 138). He continues, “mathematics is a metaphor for national supremacy, economic preeminence, and a resolute citizenry” (p. 138).

He ultimately advocates for the Deweyian Discovery School over the Disciplinary School and, consistent with Dewey’s disavowal of disciplinary hierarchy, invites us to consider implementing “PATH” instead of “STEM”, the former standing for “Philosophy, Art, Theology, History,” or perhaps, “Poetry, Anthropology, Theater, Humanities”, as a critical response to the view that the future of our society depends more upon science, technology, engineering, and mathematics than upon the range of human endeavors that are crucial for culture and civilization itself (p. 11).

Despite initially making a Deweyian argument that STEM disciplines should provide learners the capacity to make better sense of their lived experiences, Bybee (2013) moves away from Dewey by proffering STEM literacy as a means for not only students’ occupational futures, but also the nation’s economic and political security. These latter aims threaten the efficacy of the former, delimiting the extent to which what is taught and learned in schools emerges from authentic student interests. Bybee’s proffering of STEM education as a key facet for maintaining American geopolitical supremacy thus portends an illiberal educational experience for students.

George Counts (1978 [1932]) echoed Dewey’s concerns about illiberal education and argued that economic and political forces were coopting educational aims. In *Dare the School Build a New Social Order*, he warned that, “Almost everywhere the [existing school] is in the

grip of conservative forces and is serving the cause of perpetuating ideas and institutions suited to an age that is gone (Counts, 1978, p. 3). Industrialism and its institutions were archaic and insidious to Counts, and he elaborated upon their consequences:

Here we have imposition with a vengeance, but not the imposition of the teacher or the school. Nor is it an enlightened form of imposition. Rather it is the imposition of the chaos and cruelty and ugliness produced by the brutish struggle for existence and advantage. Far more terrifying than any indoctrination in which the school might indulge is the prospect of our becoming completely victimized and molded by the mechanics of industrialism. (pp. 23 & 24)

Counts implicated capitalism, too, in his analysis and posed incisive questions about the role of the school in this order. He enjoined that,

fundamental changes in the economic system are imperative. Whatever services historic capitalism may have rendered in the past, and they have been many, its days are numbered. With its deification of the principle of selfishness, its exaltation of the profit motive, its reliance upon the forces of competition, and its placing of property above human rights, it will either have to be displaced altogether or changed so radically in form and spirit that its identity will be completely lost. (p. 44)

He ultimately proposed that students, teachers, and the school be instruments for egalitarian socio-economic change, arguing that the teaching profession could and should be tasked with seeking and using “power fully and wisely in the interests of the great masses of the people” (p. 27). He also contended that teachers should seek structural change in their everyday lives and that they “must bridge the gap between school and society and play some part in the fashioning of those common purposes which should bind the two together” (p. 28).

He expounded upon this vision by calling for schools to “become centers for the building, and not merely for the contemplation, of our civilization” (p. 34). He reasoned that although schools should not necessarily become platforms for the explicit promotion of reforms, they should become places in which educators “give to our children a vision of the possibilities which lie ahead and endeavor to enlist their loyalties and enthusiasms in the realization of the vision” (p. 34). He added that in accordance with this conceptualization of schools as centers for cultivating egalitarian social imaginaries, “our social institutions and practices, all of them, should be critically examined in the light of such a vision” (p. 34).

More recently, the late political scientist Sheldon Wolin (2008) examined the American socio-political, -economic, and educational status quo, invoking concepts like *Superpower*, *inverted totalitarianism*, and *managed democracy* to make sense of the macrocosmic socio-economic and political forces that affect us in our everyday lives as citizens, consumers, and learners. He contends that the United States is not, in fact, a democratic entity, but an antidemocratic empire. Indeed, he argues that the Founders never intended for the United States to be a democracy. He takes us back to their deliberations and posits that they envisioned for the United States a system of government that actively curtailed the putative dangers of popular democracy: a republican, as opposed to a democratic, system.

He explains that within a republic, only a small group of elites, “the Few”, invest themselves with political power, leaving the rest of the citizenry, “the Many”, at once powerless

and coerced into thinking that they have political power by having access to the voting booth. In reality, the potency of popular suffrage, and thus political democracy, is purposefully mitigated by the Electoral College, which shunts real decision-making power back into the hands of political elites who have the ultimate say over whom to elect to the Executive. From the very inception of the United States, then, its elites have carefully tended to a system in which democracy is “managed” rather than unleashed. Wolin writes, “Managed democracy is centered on containing electoral politics; it is cool, even hostile toward social democracy beyond promoting literacy, job training, and other essentials for a society struggling to survive in the global economy. Managed democracy is democracy systematized” (Wolin, 2008, p. 47).

He notes that there have been historical moments in which managed democracy ceded ground to expressions of popular democracy. Roosevelt’s New Deal, for example, with its sweeping social democratic reforms stands as a prime example. But he also explains that the social and political pivots toward a more egalitarian socio-economic system were lost to the demands of a burgeoning corporate-state during World War II and throughout the Cold War era. The New Deal and its socio-economic egalitarianism even lost support from its most kindred champions: liberals. He writes, “Neoliberalism emerged as the New Deal’s residuary legatee and found its icon in JFK,” and adds that, “Its proponents were willing to sacrifice some elements of social democracy in order to promote a ‘strong state’ for opposing Soviet communism abroad” (p. 221). He explains, however, that it was due to 1950s McCarthyism that “New Deal values of social democracy were effectively purged from the national power imaginary”, writing that,

Many of the public officials, trade union leaders, intellectuals, and academics who were villified or purged actually adhered to the social democratic ideals and programs of the New Deal; this suggested that a domestic power struggle was in the making that would redefine American politics for the next half century or more. (p. 38)

It was thus during the Cold War era that the United States experienced a symbiosis of corporations and state, an amalgam that henceforth nourished antidemocratic, imperialist tendencies within the country’s political system. He writes,

The development of an extended relationship between the military and the corporate economy began in earnest. National defense was declared inseparable from a strong economy. The fixation upon mobilization and rearmament inspired the gradual disappearance from the national political agenda of the regulation and control of corporations. (p. 34)

If its founding elites sought to inculcate within the United States’ very social, political, and juridical DNA the dictates and practices of a republican, and not a democratic, system of governance, therefore, the country would evolve into a corporate-state bent on defending itself at all costs from foreign, communist adversaries by amalgamating capitalism with democracy and embracing science and technology, as well as the expanded military with which they came.

Wolin contends that at present, the United States stands as a 21st century imperialist system, the corporate elites of which continue to seek increased power and profit through foreign domination via Superpower, and domestic servitude via inverted totalitarianism and managed democracy. To differentiate between how the United States expresses imperialistic power globally as opposed to domestically, he uses the term “Superpower” to capture the empire’s outward projection of power for foreign domination and expansionism. On the other hand, he

suggests that “Superpower” has its inverse and domestic equivalent in “inverted totalitarianism”, or the Empire’s inward projection of power for popular suppression. He argues further that managed democracy relates to inverted totalitarianism insofar as it is the everyday expression of inverted totalitarianism: its “fair and balanced” news programs, its stabilizing two-party system, its welcoming voting booths, its “smiley face” (p. xvi).

He explains that American inverted totalitarianism represents “the *political* coming of age of corporate power and the *political* demobilization of the citizenry” (p. x). Whereas German Nazi and Italian Fascist regimes deemed the political mobilization of their citizenries to be key to the attainment of their revolutionary political agendas, contemporary American corporate elites within a regime of inverted totalitarianism require a politically apathetic, feckless, complacent, and benign citizenry to consolidate power and profit.

This symbiosis of private and state power thus poses a dire threat to systems of public education and public institutions writ large. He writes that, “To the extent that the corporation and state are now indissolubly connected, ‘privatization’ becomes normal and state action in defiance of corporate wishes the aberration. Privatization supplies a major component of managed democracy” (p. 136). He continues to argue that under the corporate-state and its system of managed democracy, “A traditional governmental function, such as education, is in the process of being redefined, from a promise to make education accessible to all to an investment opportunity for venture capital” (p. 136).

Wendy Brown (2015), Wolin’s former student, has recently examined the effects of neoliberalism upon society. Though she agrees that neoliberalism can and should be understood in part as a term used to describe economic policy decisions, she is more interested in how neoliberalism as a form of political rationality has come to influence the ways in which individuals see the world, others, and themselves. She argues that a defining feature of neoliberalism, “neoliberal reason”, is “ubiquitous today in statecraft and the workplace, in jurisprudence, education, culture, and a vast range of quotidian activity,” and that it is “converting the distinctly *political* character, meaning, and operation of democracy’s constituent elements into *economic* ones” (Brown, 2015, p. 17).

She is careful to discern between two intensifications of neoliberalism: first “as an order of normative reason”, which then, “when it becomes ascendant, takes shape as a governing rationality extending a specific formulation of economic values, practices, and metrics to every dimension of human life” (p. 30). She describes the broader reality within which the modern, depoliticized subject finds itself:

The institutions and principles aimed at securing democracy, the cultures required to nourish it, the energies needed to animate it, and the citizens practicing, caring for or desiring it — all of these are challenged by neoliberalism’s ‘economization’ of political life and of other heretofore noneconomic spheres and activities. (p. 17)

She clarifies that “economization” is not synonymous with “monetization”, though neoliberalism can and does involve the monetization of non-monetized, or otherwise should-be non-monetized, domains, like elections (p. 31). Rather, by claiming that neoliberalism “economizes” “political life and ... heretofore noneconomic spheres and activities”, she makes a broader point about the nature of neoliberalism as “a distinctive mode of reason, of the production of subjects, a ‘conduct of conduct,’ and a scheme of valuation” and how it affects the subject and its world (p. 21).

After Foucault, Brown accounts for the experience of the individual by understanding it as a subject constructed by various socio-political and economic forces. This leads her to utilize non-gendered categories of subjectification to account for the ways in which individuals' experiences and comportment with these macrocosmic forces have changed over the decades and even centuries. More specifically, she claims that the individual has experienced subjectification as *homo politicus* and *homo oeconomicus*. The term *homo politicus* roughly denotes a subject constructed in accordance with the norms and dictates of a political system, while the term *homo oeconomicus* roughly denotes a subject constructed in accordance with the norms and dictates of an economic system. She argues, however, that there is no necessary fixity to the nature of the instantiations of the subject. With respect to *homo oeconomicus*, for example, she explains that, "Contemporary neoliberal rationality does not mobilize a timeless figure of economic man and simply enlarge its purview. That is, *homo oeconomicus* does not have a constant shape and bearing across centuries" (p. 32).

She contends that *homo oeconomicus* today exhibits an intensified form of self-capitalization, with elements of interest and profit seeking entrepreneurship. She states,

Today, *homo oeconomicus* maintains aspects of that entrepreneurialism, but has been significantly reshaped as financialized human capital: its project is to self-invest in ways that enhance its value or to attract investors through constant attention to its actual or figurative credit rating, and to do this across every sphere of its existence. (pp. 32 & 33)

When positing that the contemporary subject under neoliberal reason attempts to self-invest within "every sphere" of its existence, she isn't exaggarating: She even goes so far as to suggest that neoliberal reason has infiltrated and transformed the dating game, now replete with its litany of websites designed for maximizing individuals' romantic investment potential (p. 31).

Thus, the extent to which the contemporary subject has been constructed according to the norms and dictates of neoliberal reason could be considered alarmingly total. More specifically, in the era of finance capital, she suggests that contemporary *homo oeconomicus*, or human "capitals", are formulated in accordance with the model of the contemporary *firm* (p. 36). Contemporary *homo oeconomicus* as itself a self-investing firm thus conceives of present experiences as investment opportunities for future status. When suggesting that human capitals are seizing investment opportunities in the present to secure future value, she argues that the stakes could not be higher: Under the present regime of the neoliberalized state, human capitals seek present investment opportunities to secure nothing less than survival itself, as the evisceration of social safety nets within an era of intensified competition leave human capitals with no room for error.

This regime of competitiveness and survival has also begun to quash educational institutions as spaces in which learners become cultivated into an informed citizenry. Educational institutions have thus been transmogrified into spaces in which human capitals fight for educational, and ultimately occupational, opportunities. She explains, "In recent years, this premise has given way to a formulation of education as primarily valuable to human capital development, where human capital is what the individual, the business world, and the state seek to enhance in order to maximize competitiveness" (p. 176). What, then, does this radical reconstitution of the individual as self-investing, incorporated, *homo oeconomicus* under a

regime of state neoliberalism and neoliberalized education mean for the status of the citizen and democracy itself?

She suggests that the outlook for both is grim, and this leads us to consider her views on *homo politicus* as a vital category of subjectification for the liberal state. First, she explains that political life is but one of the spheres of human activity and interest that neoliberal rationality has infiltrated and transformed. When it does spread to this sphere of activity, however, it “transposes democratic political principles of justice into an economic idiom, transforms the state itself into a manager of the nation on the model of a firm ... and hollows out much of the substance of democratic citizenship and even popular sovereignty” (p. 35). Second, she explains that at the level of the subject under these conditions, the category of *homo politicus* becomes “vanquished”, writing that, “one important effect of neoliberalization is the vanquishing of liberal democracy’s already anemic *homo politicus*, a vanquishing with enormous consequences for democratic institutions, cultures, and imaginaries” (p. 35). She contends that the vanquishing of *homo politicus* under the current neoliberal regime entails “enormous consequences for democratic institutions, cultures, and imaginaries” because it appears that liberal democracy itself relies upon the a priori existence of *homo politicus* to exist, bearing in mind her qualification that *homo politicus* itself has historically existed and could still exist without the liberal democratic form of government.

More specifically, *homo politicus* entails the presence of the human “being”, and not the human “capital”, which can and does avail itself of the political and civic rights and responsibilities that both stem from and safeguard popular sovereignty. If liberal democracy is contingent upon a populace that seeks and attempts to protect such things as self-governance, equality, and justice and neoliberal rationality has almost completely undercut the popular basis upon which liberal democracy can and must survive, then liberal democracy appears fated to dissolution with the dissolution of *homo politicus*. And as Brown reminds us, imperiled, too, are those more politically radical imaginaries that liberal democracy inspires us to consider. With the potential dissolution of liberal democracy, the door is open to various instantiations of illiberal forms of government, including authoritarian, oligarchic, technocratic, and (writing in 2018) kakistocratic rule.

In *Philosophy of STEM Education: A Critical Investigation*, Nataly Chesky and Mark Wolfmeyer (2015) have extended a commensurate analysis to STEM education. As teacher educators in math and science, former public-school mathematics educators, and parents with young children, they express profound concern with the nature and aims of STEM education, arguing that its policy discourse reveals emphasis on “the teaching of mathematics and science ... as merely a utilitarian activity needed for technology and engineering skills that are used to further a nation’s economic power” (Chesky & Wolfmeyer, 2015, p. xi). They add, “And we did not believe that our children’s happiness and success equated to their ability to trump their peers and compete with their neighbors, locally or globally” (p. xi).

In their analysis of STEM education policy, they seek to examine its “foundational principles”, “fundamental terms”, and “covert agendas”, which, they think, “could encompass cultural, social, political, and philosophical perspectives” and include “the economic and militaristic imperatives in STEM” (pp. 6 & 7). They add that deep analysis of STEM policy is necessary “If we hope to counter balance the neoliberal rhetoric that has so permeated educational policy discourses in the United States” (p. 9). They suggest that it is within STEM policy that neoliberal rhetoric is strongest. They even go so far as to claim that STEM

educational policy could be “the most influential, most oppressive, and potentially the most revolutionary educational policy of our time” (p. xiii).

What follows is an analysis of the nature of STEM education policy that is focused on the latent aims within the literature and how they align with broader philosophical conceptions of what is true, good, right, and beautiful. They ultimately argue, however, that the discourse appears to be controlled by political and economic, or corporate, elites who utilize it as an instrument of power and profit that dominates and oppresses students and educational institutions. They contend further that the discourse construes disciplinary content as absolutist, pedagogy as traditional, and aims as utilitarian. In other words, they charge that it frames disciplinary knowledge as unquestionable, pedagogy as authoritarian, and aims as instrumental to the maintenance of state and corporate power (Chesky & Wolfmeyer, 2015).

The preceding analysis would thus suggest that because Bybee’s case ultimately supports the maintenance of a powerful state apparatus within a competitive, capitalistic economic system, it represents an “establishment” position and even exudes a “right-authoritarian” political valence (Wikipedia, 2018). Invoking Wolin and Brown’s lexica, it could also be said that Bybee’s case renders STEM education an instrument of the corporate-state, in service to nationalism, militarism, and ultimately American imperialism and consistent with the forms of education human capitals must seek within this milieu to bolster their market value as walking firms. Noting preceding critics’ observations that socio-political, economic, and educational forces are working in concert to decimate public institutions, democracy, and even the demos itself, it becomes evident that to protect the vestiges of liberal democracy, such proposals that support and can reify the status quo should be countered and displaced.

Educational Alternatives

With its de-emphasis on, and even disavowal of, state power and capitalism and emphasis on communal governance and collectivism, the political orientation of left-libertarianism could provide effective responses to right-authoritarian educational reform proposals and the status quo itself. In *Anarchism and Education*, Judith Suissa (2010) has offered an extensive analysis of the nature and role of education within left-libertarian thought and, more specifically, the economically-left ideology of social-anarchism as opposed to the economically-right ideology of libertarian anarchism.

She contends that anarchism has been much maligned for its reputed promotion of a social utopia which it could never practically deliver but takes issue with the charge. She argues that latent within any given population are the seeds for anarchic life: People are already cooperative, provide to one another mutual aid, exchange acts of kindness, share their possessions, and travel within nonhierarchical groups. And she argues that the very practice of social-anarchist ideals within the current socio-economic structure represents realizations, all be they localized, of social-anarchism itself (Suissa, 2010).

Because education within social-anarchism, or “integral education”, is a vital component for cultivating within society’s members the kinds of moral dispositions requisite for self-, nonhierarchical, and decentralized governance in a stateless society, the distinction between the putative means and ends of education within social-anarchist education collapses. In this vision, the doing of education is the very fulfillment of the kind of society it seeks to bring about. Suissa writes,

Taking the social-anarchist perspective seriously, then, can help us think differently about the role of visions, dreams, goals and ideals in educational thought. It suggests that perhaps we should think of education not as a means to an end, nor as an end in itself, but as one of many arenas of human relationships, in which the relation between the vision and the ways it is translated into reality is constantly experimented with. (Suissa, 2010, p. 146)

Jennifer Logue and Cris Mayo (2009) generally commend Suissa's examination of social-anarchism and social-anarchist education but criticize the extent to which she neglects to address the efficacy of other critical and related educational frameworks. They write, "It is perhaps equally interesting that Suissa does not examine what we might take to be philosophical cousins to anarchism—those oppositional political theories and practices that do cut against the accepted norms or organisations of social and political institutions" (Logue & Mayo, 2009, p. 160).

They explain Suissa's selectivity by arguing that her account, and social-anarchism itself, is weak in comparison to the related frameworks in accounting for the nature and role of power within social systems. Social-anarchism's putative inability to adequately address and respond to unequal power dynamics within the current state-based socio-economic system also reveals itself within integral education's lack of an adequate account and utilization of pedagogy as a political means for broader social change. Integral education's lack of focus on socially transformative pedagogy could thus indicate the need to incorporate tenets of critical pedagogy into an educational framework that could effectively respond to oppression.

Abraham DeLeon (2006) offers another perspective on social-anarchism and critical pedagogy and their potential integration into an activist educational framework. He argues that, "Combining anarchist theory and critical pedagogy in the individual classroom could be quite powerful, and introducing students to these critical traditions may help bring change much more quickly to public schools" (DeLeon, 2006, p. 88). More specifically, he suggests that critical pedagogy could serve as the foundation for an activist framework, whereas "anarchist micro-strategies ... can help instill direct action into critical pedagogy that is often criticized for not linking theory with praxis" (p. 88).

Interestingly, though both Logue and Mayo and DeLeon argue that social-anarchism and critical pedagogy share many similarities, they interpret the frameworks differently. For example, Logue and Mayo see critical pedagogy as an invaluable means for socio-economic change and argue that social-anarchism fails to provide adequate pedagogical methodologies, stating that, "Critical pedagogy seeks to change oppressive social relationships in the here and now, and it sees education as central to creating personal and social transformation" (Logue & Mayo, 2009, p. 164). But DeLeon sees broader social activism and struggle (i.e., street activism) as an invaluable means for socio-economic change and argues that critical pedagogy fails to provide adequate avenues for political struggle outside of the classroom's walls.

As a mirror image to Logue and Mayo's latter quote, DeLeon writes that, "what anarchist theory brings is a sense of urgency and faith in individual and cooperative direct action that is lacking in many of our radical discourses surrounding schooling and our educational experiences in the United States" (DeLeon, 2006, p. 89). Ultimately, however, the authors refrain from fleshing out full theoretical accounts that combine tenets from both social-anarchist education and critical pedagogy, leaving this work for future scholarship.

Chesky and Wolfmeyer's alternative conceptualization of STEM education might just be a fitting reply to Logue and Mayo's and DeLeon's recommendations. Tellingly, three years prior to the publication of *Philosophy of STEM Education*, Wolfmeyer (2012) had investigated how mathematics as a "knowledge" could be coopted in various ways and for different educational and societal aims, including those of anarchism. He expresses regret, however, over the extent to which mathematics has been coopted for various "societal ills", including as a means for widening the income disparity between the working- and upper-classes and as a means to the development of racist statistical measures that were biased in favor of whites. He suggests that such uses of mathematics for societal ill are actually "antianarchist" in nature, as they run counter to what he identifies as the three fundamental values of anarchism: equality, fraternity, and freedom.

He goes on to make the case that despite mathematics' historically antianarchist usurpation, the knowledge can, in fact, be organically integrated into anarchism generally and anarchist educational programs particularly. It should also be noted that one of the most important aspects of an anarchist mathematics approach is that it is open to interpretation by members who experience it. In other words, he suggests that whatever is taught in this approach should also be able to be discarded if students and educators decide that it is not worthwhile.

Chesky and Wolfmeyer's (2015) alternative conceptualization of STEM education integrates aspects of both anarchism and critical pedagogy. Indeed, they point out that presenting the STEM disciplines as aesthetic and transformative is contingent upon the Freirean notion of knowledge as power (p. 92). Ontologically, they seek a "post-modern conception of STEM subjects" (p. 76). Science education, for example, should undergo a shift away from the privileging of science as a sole claimant to truth and rationality and a framing of technology as a harbinger of progress without long-term consequences. They suggest that a critical science education could and should play a role in framing the potential dangers of western science and technology. Like Dewey, they argue that this position should also value "a nature of science where scientific knowledge production is *placed within* social life" (p. 80).

Epistemologically, they call for a transformative "pedagogy of truths" (p. 82). In this vision, they see an example of an ethnomathematics lesson as providing a foundation for an alternative epistemological vision of STEM education. It entails the exploration and reproduction of the Indian cultural, ecological, and artistic symbol of the Kolam, which is made of colored rice powder. Engagement with this cultural artifact touches upon their support of an ontologically aesthetic, epistemologically transformative, and axiologically democratic alternative STEM education because it posits neither an absolutist nor a fallibilistic ontology of mathematical properties, as evidenced in the putative teaching and learning of the complicated math that underlies the artifact, but math that underpins a complicated artistic design and an exploration of the culture and the people for whom this artifact is important, including an examination of this culture's belief in ecological harmony.

Axiologically, they call for the advancement of "social justice and sustainability" and posit that STEM education need not be explicitly "useful", that teachers and learners in this vision should have the freedom to pursue topics for the inherent value of the topics themselves (p. 85). They state, "It is our intention that such appreciation will further ground mathematics and science among the other cultural efforts, like art or music, rather than continue to elevate it to a superior status" (p. 89). They capture how their conceptualization amalgamates anarchist

education's permission of pedagogical experimentation with critical pedagogy's emphasis on the mitigation of socio-economic and educational inequality when they write,

Thus, we reimagine the axiological objectives of STEM education to be centered around not only imagining sustainable technology, but also about harnessing aesthetic awareness, drawing on environmental-sensibilities, awakening cultural, gender, and class critical consciousness, and about nothing at all. Indeed, we hope that educators can engage in the act of teaching and learning mathematics and science to forget, if only for a moment, the mandated 'student learning objectives' and allow the teaching act to be about the pure joy of experiencing the content together for no external purpose whatsoever. (p. 89)

They go further to frame their alternative conceptualization as revolutionary but qualify "revolution" in a strikingly anarchist way as "a subtle introspective creative process that although happens under the situation as it stands, slowly but surely erupts to change society completely" (p. 93).

While I consider Chesky and Wolfmeyer's alternative conceptualization to be a promising avenue for STEM education, I do have reservations. Using Logue and Mayo's and DeLeon's analyses to calibrate the extent to which a reform proposal balances anarchist and critical pedagogical approaches, their proposal feels light on critical pedagogical activities designed to intentionally address features of the corporate-state. I propose that an anarcho-critical STEM education that is explicitly focused on analyzing state power, or that is "state-critical," could offer students opportunities to bring the STEM disciplines to bear on facets of American imperialism, including corporate malfeasance, discriminatory urban and educational planning practices, and unethical and unlawful military exploits. Below are several ideas for resultant units or courses of study that might exist at the high school or undergraduate levels:

"Seedy Politics" could be offered as a science course and would entail the examination of the aims and practices of big agriculture. One of its cases could entail an examination of Monsanto's monopolization of seed distribution to Iraqi farmers after the destruction of the country's seed banks, and thus the decimation of Iraqi wheat production, during the Iraq War. It could enjoin participants to grow Iraqi wheat to not only reveal the difficulties with and beauty of attempting to cultivate an indigenous agricultural product, but also connect participants with the plight of another country's citizens.

"Green Technologies" could be offered as a technology or biology course and would entail students learning about the science and history of green energy technologies, including the debates surrounding them and the sources of and reasons for political and corporate resistance to their implementation. It would approach the efficacy of green technologies empirically and incorporate evidence for their effectiveness and, in certain cases, ineffectiveness. Students could thus be challenged to imagine ways in which certain technologies could be improved and others invented. They could also be asked to critically assess their own school's uses, and potential misuses, of energy resources and be enjoined to develop and incorporate an example of green technology for their classroom's energy needs, such as a small wind turbine or solar grid on school property. Potential resistance to the incorporation of green technology on school property could be integrated into the course as an issue for critical analysis.

"Working Robots" could be offered as a technology course and would entail students learning about the science and use of robots in previously human-based work and proceed to

consider the possible future uses of robots in myriad labor sectors. It would demand a careful philosophical and ethical treatment of the displacement of human with machine laborers, posing critical questions about the effects that a reduction in opportunities for human labor could have on working populations. It could also consider the capitalistic motives underlying the shift toward machine laborers and query economic alternatives to the dominant model. Students could also be asked to design and develop a working robot of their own, be challenged to put the robot to school or domestic tasks, and be enjoined to think about both the gains and costs the introduction of machine labor creates.

“Bridges to Nowhere” could be offered as an engineering course and would entail critical examinations of potentially discriminatory architectural and city planning practices. For example, participants could critique Robert Moses’ mid-20th century city planning practices and the extent to which these were discriminatory against people of color. Participants could then work to reengineer selected designs and structures to achieve equity.

“Discipline and Schooling” could be offered as an engineering course and would entail students learning about the inherently ideological nature of architectural design. It could consider Foucault’s thoughts on the Panopticon as an idealized mode of surveillance and the extent to and ways in which the modern school uses it. It could also consider the predominant use of the Panopticon in schools within lower SES communities and populations of color. The course would challenge students to ask incisive questions about the nature and purposes of disciplinary structures and the putative reasons for their usage within certain communities. Students could also be asked to design their own school and be challenged to consider the role, or absence, of discipline within their designs (Gallagher, 2010).

“Drones and Duties” could be offered as a technology course and would entail students inquiring into the ethical dimensions of technology and working collaboratively to research, design, and build a drone they would eventually fly. Because they would fly the craft, they would have to research the guidelines and laws restricting its use. Students would then consider their duties given these restrictions. It would progress to consider the various and future uses of drones in society and address the ethics of using drones in warfare to remotely kill combatants. Students would thus need a robust ethical framework to informatively discuss the militaristic use of drone technology.

Conclusion

I hope to have problematized Ossola’s (2014) declaration that STEM education is simply “justified”. Dewey, Hacker, Counts, Wolin, Brown, and Chesky and Wolfmeyer provide argumentation to support the contention that STEM educational reform proposals like Bybee’s can be complexly illiberal and in service to the maintenance of the corporate-state and American imperialism. I have suggested that left-libertarian strategizing could be effective for countering the dominion of a right-authoritarian status quo and have proffered Suissa, Logue and Mayo, DeLeon, Wolfmeyer, and Chesky and Wolfmeyer’s thinking about education as apposite responses. I have also concluded that Chesky and Wolfmeyer offer a promising avenue for STEM education in their anarcho-critical conceptualization but argue that it could further implement critical pedagogy by providing students with opportunities for learning explicitly about the contours of American imperialism.

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Author

Jamie E. Teeple is a PhD candidate in Educational Studies at The Ohio State University. His research focuses on developing social reconstructionist approaches to education. He can be reached at teeple.16@osu.edu.

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