A Philosophical Analysis of STEM Education

Dissertation

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Jamie Eric Teeple

Graduate Program in Educational Studies

The Ohio State University

2018

Dissertation Committee

Bryan R. Warnick, Advisor

Michael J. Glassman

Bruce A. Kimball

Abstract

In this dissertation, I critique STEM education as the educational apotheosis of neoliberal governmentality and reconceptualize it for an egalitarian democracy. Part and parcel of this analysis is considering Wendy Brown's (2015) contention that the contemporary subject is interpolated by the prevailing norms of neoliberalism as a governing form of political rationality and thus expresses itself not as a political subject, or "homo politicus", but as a self-investing and economized subject, or "homo oeconomicus". I hypothesize that students as emergent homo oeconomicus seek out STEM education as the best means for survival within a technocratic marketplace. In this sense, STEM literacy is rendered the paradigmatic form of symbolic capital within the capitalist state. The thrust of my critical response to this milieu figures left-libertarian or social-anarchist thought as the diametrically opposed and thus apposite ideological rejoinder to the right-authoritarian status quo, not only for political activism writ large, but also for educational reform proposals and even the preparation of preservice teachers. In the end, my research is an attempt to explore how students' narratives can assist critical educators with leveraging pedagogy into a potent means for cultivating within educational systems the social imaginaries and political subjects needed to eschew the aims of a right-authoritarian status quo and embrace the aims of an egalitarian, left-libertarian society-to-be.

Dedication

For Kristen.

Acknowledgments

I would like to begin by thanking my teachers, colleagues, and peers. Without your patient guidance and invaluable advice, I would never have been able to produce this document. In particular, I would like to acknowledge Bryan Warnick, Bruce Kimball, Michael Glassman, Phil Smith, Shirley Yu, Karen Graves, Emily Nemeth, and Suzanne Baker. I would also like to acknowledge my family. Without your care and unwavering support, this road would have been far bumpier. Mom, you are the greatest educator I have ever known. Jennifer, you are my coconspirator. And Kristen, my love and my life, I cannot wait to see what our future holds.

Vita

Work

August 2018-May 2019: Denison University: Visiting Instructor

August 2017-May 2019: Columbus State Community College: Adjunct Instructor

Education

2013-2018: The Ohio State University, College of Education and Human Ecology: Seeking Doctor of Philosophy Degree

2011-2013: The University of Toledo, Judith Herb College of Education: Master of Education Degree

2004-2008: McGill University, Faculty of Arts: Bachelor of Arts Degree

Publications

October 2018: Teeple, J. E. Toward a state-critical STEM education. *Critical Education*, *9*(16), 67-83.

March 2018: Kuznetcova, I., Teeple, J., & Glassman, M. The dialectic of the avatar: Developing in-world identities in Second Life. *Journal of Gaming & Virtual Worlds*, *10*(1), 59-71.

Fields of Study

Major Field: Educational Studies

Specialization: Philosophy of Education

Table of Contents

List of Figures

Chapter 1. Introduction

My overarching aim in this dissertation is to challenge the claim that STEM education passes, tout court, as a "justified" educational reform discourse (Ossola, 2014). To inquire further into its nature and ask questions about its putative interpretations and uses, I undertake several analyses centered on the competing interpretations, socio-economic underpinnings, lived experience, and future of STEM education.

In Chapter 2, I provide an overview of the emergent debate over STEM education. A cursory assessment of the phenomenon and its history reveals competing and even contradictory assertions about its nature. STEM education is at once a buzzword, a collection of subjects, a pedagogy, a reform movement, a solution to American economic stagnation, a boon for mathematics and science education in particular, an advocacy position for special interest groups, a national policy platform, and a threat to liberal arts education.

In Chapter 3, I move beyond this cursory assessment and work toward a deeper, philosophical understanding of STEM education. I first explore preceding theoretical critiques of education and the status quo, including John Dewey's (2012 [1916]) admonition of the instrumentalization of education as a means for extrinsic and economic interests, George Counts' (1978 [1932]) observation that economic and political forces were coopting educational aims in the first half of the 20th century, and Jean Anyon's

(1980) pioneering critical study of New Jersey public schools and their role in class reproduction in the 1980s. I then review Henry Giroux's (2013) more recent argument that state-capitalism has intensified and threatens the existence of democratic education, liberal democracy, and the social state. I subsequently attempt to elucidate the phenomenon of "the state" by referring to selected definitions but return to Giroux's argument that contemporary state-capitalism portends the emergence of authoritarianism in the West. To expand upon these arguments, I continue to utilize, draw from, and think through the critical theoretical tradition as an organizing theoretical framework, turning to political scientist Sheldon Wolin's (2008) oeuvre on the state of liberal democracy in the 21st century which claims that the United States stands as an imperial system, exerting its power externally as "Superpower" and domestically as "inverted totalitarianism" and "managed democracy". I highlight his history of the Cold War era and the amalgamation of the state and corporate power and his argument that corporatist forces threaten educational systems within the current regime. I then turn to Wendy Brown (2015), Wolin's former student, and her analysis of neoliberalism as a dominant form of political rationality and governmentality. Her assertion that contemporary subjects comport as economized rather than politicized beings further explicates the lived experience of American empire and the extent to which a corporate-induced, mass political complacency permits liberal democracy to wither on the vine. Like Giroux and Wolin, Brown argues that rampant privatization endangers the functioning of educational institutions as cultivators of citizens as "homo politicus" and contributes instead to the

transmogrification of education as a means for the economic survival of "homo oeconomicus" and corporate power.

In Chapter 4, I apply these ideas to a critical discussion of STEM education. I begin by connecting the foregoing theoretical critique to Nataly Chesky and Mark Wolfmeyer's (2015) philosophical investigation of STEM education, which makes the case that STEM education is the apotheosis of neoliberalized educational reform. I also illustrate how their analysis of the STEM educational policy discourse aligns with the conceptualization and treatment of policy documents as social artifacts that impact the nature of dominant culture. I then extend the idea of analyzing educational documents, including contemporary cases for STEM education, as social artifacts within the process of dominant cultural reproduction by completing a comparative case study of two recent and notable works on STEM education: the first by Rodger Bybee (2013) and the second by Andrew Hacker (2016). I contend that these two texts serve as excellent examples of two distinct positions on STEM education, and after reviewing and comparing them, I focus on a critique of Bybee's case and the extent to which it expresses an ideological orientation toward conservatism, and namely the conservativism of the 1980s which saw an embrace of the excellence agenda in the National Defense Education Act (NDEA) of 1958 and the push for positivistic and standards-based educational reform leading into the 1990s. I subsequently subject Bybee's case to the arguments of scholars who have been critical of this conservative turn toward excellence and in support of an equity orientation toward educational reform. I contend that Bybee's case never questions the efficacy of the status quo, and in doing so, serves as an instrument of the corporate-state and

neoliberal governmentality and is thus an illiberal educational option. I suggest that cases like Hacker's offer authentically progressive options for future STEM educational initiatives but concede that even Hacker's case does not go far enough to respond to the issues Chesky and Wolfmeyer's case elicits, namely the existent of oppressive socio-economic forces and their influence over educational policy and planning. I conclude, however, by invoking the Vega model to challenge Chesky and Wolfmeyer's claim that students' lived experiences fall outside of the purview of a philosophical investigation of STEM education and argue instead that the experience of STEM education is an inextricable facet of the process of dominant cultural reproduction and thus has enormous philosophical value. Thus, before turning to conceptualizations of STEM education that might address the need for responding to the status quo, I proceed to consider STEM education as an enacted and lived phenomenon.

In Chapter 5, I first address Mark Wolfmeyer's (2012) critique of corporations Boeing and Battelle in their involvement in the militarization of STEM education. This serves as a prelude to my analysis and discussion of 22 middle school students' perceptions of STEM education at a Battelle-funded, STEM-focused college-preparatory school. I subsequently utilize Wendy Brown's figuration of the contemporary subject as "homo oeconomicus" to inform my examination of the extent to which students' narratives indicate their hegemonic socialization as economized subjects under conditions of neoliberal political governmentality. I report that the data suggests evidence of such socialization. I also conclude, however, that it points to students' ideological indeterminateness and the possibility that educational intervention could stymie

hegemonic socialization and cultivate subjectification as "homo politicus" instead, challenging Brown's certitude about the pervasiveness of neoliberal subjectification. Ultimately, I attempt to illustrate how students' narratives can tell us more about the nature of STEM education within the status quo and guide us toward developing forms of STEM education that could foster a critical citizenry for a democratic society.

In Chapter 6, I seek a conceptualization of STEM education that could foster students' subjectification as political beings for a democratic society. I draw upon the work of Erick Heroux (2010) and Judith Suissa (2010) to explore the extent to which the socio-economic ideology of social-anarchism and social-anarchist education could provide effective responses to hegemonic socialization within a right-authoritarian status quo. I also imagine the composition of STEM education within an anarchic or stateless society. I temper this inquiry by alluding to Noam Chomsky's (2016) prudent thoughts on the limits of anarchic activism within a state-based society and proceed to offer scholars' suggestions for practical reform. I then turn to Jennifer Logue and Cris Mayo's (2009) critique of social-anarchist education and Abraham DeLeon's (2006) attempt to amalgamate social-anarchist education with critical pedagogy into an efficacious critical educational approach. I subsequently review Chesky and Wolfmeyer's alternative, social justice-oriented conceptualization of STEM education and draw upon Suissa, Logue and Mayo, and DeLeon to calibrate the extent to which their vision balances elements of social-anarchist education and critical pedagogy. I conclude, however, that it expresses a closer relationship to the former than it does to the latter and contend that, in doing so, it falls short of providing an approach to STEM education that would be capable of

exposing and challenging facets of the corporate-state, like corporate malfeasance and the military industrial complex and its exploits. I consequently propose a conceptualization of STEM education that is "state-critical" or focused on bringing the STEM disciplines to bear upon explicit and sustained critiques of state-capitalism and American imperialism in schools. This proposal takes the form of a review of several possible courses at the upper-high-school or undergraduate level that could enact the tenets of a state-critical STEM education. I subsequently address the putative problems with this conceptualization, but also point to its possibilities.

I conclude this dissertation by reviewing its propositions and pointing to promising developments for future political and educational activism and reform. Ultimately, I contend that this dissertation is intended to show how STEM education could be leveraged into a potent means for cultivating within educational systems the social imaginaries and political subjects needed to eschew the aims of a right-authoritarian status quo and embrace the aims of an egalitarian, left-libertarian society-to-be.

Chapter 2. The Emergence of the Debate Over STEM Education

Philosopher John Dewey once wrote, "The true starting point of history is always some present situation with its problems" (Dewey, 2012, p. 228). The inscrutability of the nature of STEM education poses such a problem. In the following pages, I will explore the emergent debate over STEM education and review accounts of its history and assertions about its nature and purposes. Ultimately, this chapter, by problematizing the nature of the phenomenon, will serve as a catalyst and justification for a deeper, philosophical analysis of STEM education.

Nataly Chesky and Mark Wolfmeyer (2015) provide one concise historical account of STEM education, suggesting that contemporary thought about it can be traced back to Vannevar Bush's thinking in the 1940s. They also cite, but do not elaborate upon, Sputnik's launch, the Cold War, the National Defense Education Act (NDEA) of 1958, and the 1983 publication of *A Nation at Risk* as key factors in the evolution of the phenomenon. In a similarly concise historical account, David Drew (2011) cites the launch of Sputnik, but more emphatically presents it as STEM education's baptismal event, stating, "The first modern-era challenge to American technological leadership was the Soviet Union's successful launch of Sputnik in 1957, at the height of the Cold War" (Chesky and Wolfmeyer, 2015; Drew, 2011, p. 3).

Drew continues to describe how the National Defense Education Act of 1958 was a response to the threat of Russian technological superiority, writing that, "One response to the growing Soviet challenge was the National Defense Education Act (NDEA), which provided funding to improve mathematics and science education" (p. 3). He then explains that the development of "New Math" grew out of the thinking of the Yale University School Mathematics Study Group, funded by the NDEA and the National Science Foundation, in the 1950s (p. 3). He concludes his account by stating, almost cryptically, that "NDEA funding helped improve education, but much more support and improvement still was needed. Decades of math and science education reforms followed, some successful, some not" (p. 4).

In her historical analysis of gifted education's relationship to the NDEA and STEM educational initiatives, Jennifer Jolly (2009) points out that science, technology, engineering, and mathematics, though not referred to nominally as "STEM", have had a longstanding relationship with American initiatives, including West Point's establishment in 1802, whereupon "West Point graduates designed many of the railroads, bridges, and roads so important to this country's early expansion" and the Morrill Act of 1862, which involved the support of science and engineering programs central to the development of "colleges and universities to study agriculture and mechanical arts" (Jolly, 2009, p. 50). Citing Thomas Friedman, she states, "During the past several years, much discussion has focused on developing America's future scientists, technologists, engineers, and mathematicians (STEM) in order to remain viable and competitive in a growing global

economy" and argues that American global economic competitiveness is a central catalyst for the adoption of STEM educational initiatives in the 21st century (p. 50).

In his lengthier history of STEM education, Rodger Bybee (2013) recounts that it emerged out of events occurring in the middle of the 20th century. Granting that "The Sputnik era was a significant turning point for the STEM disciplines," he points out that "The education reform of the 1950s and the 1960s was already in progress when the Soviet Union placed Sputnik in orbit" (Bybee, 2013, p. 13). He explains that public criticism of progressive education post-Sputnik was, in fact, reminiscent of sentiments at the end of the 19th century, whereupon "critics said that students were being spoon-fed, the curriculum was too easy, and music and art took too much time from fundamentals" (p. 14). He suggests that despite similar criticisms of progressive education in the 1950s, which were rarely based on evidence, "educators did not respond to critics" (pp. 14 & 15). He adds, "There is no clear explanation for the educators' silence. Recall, however, that this was the Cold War and the period of McCarthyism, so they may have been fearful to say anything" (p. 15).

He discusses reasons for the turn away from progressive education in the 1950s, explaining that interest in progressive education in this period was on the decline, citing the collapse of the Progressive Education Association in 1955, the termination of the journal *Progressive Education* two years later, and progressive educators' introduction of "life adjustment" into the national curriculum, which "focused on the needs of students in 'general tracks' and proposed a curriculum of functional experiences in areas such as the practical arts (later to become technology education), family living, and civic

participation" (p. 15). He argues that it was the conflation of progressive educators' veritable silence to critiques during the McCarthy era, the general lack of public support for progressive education, the non-academic nature of the life adjustment curricula, and the academic educational backgrounds of critics and the general public alike that led to progressive educational ideas' capitulation to a new, widely-supported educational platform post-Sputnik, one oriented toward mathematics and science, supported by the National Defense Education Act of 1958 (Bybee, 2013).

Mark Sanders (2008) recounts that by the 1990s, science, mathematics, engineering, and technology education had found a new expression in the National Science Foundation's use of "SMET", which would eventually give way to the use of "STEM" after complaints the former sounded like "smut" (Sanders, 2008, p. 20). Alexandra Ossola (2014) also reports that Judith Ramaley, former "Assistant Director of Education and Resources at the National Science Foundation", is credited with advancing the term "STEM" in 2001 as a corrective to "SMET" (Ossola, 2014).

But Sanders (2008) points out that prior to Thomas Friedman's 2005 call to economic arms, *The World Is Flat*, relatively few people were even aware of STEM. He accounts for the rapid proliferation of STEM education at the turn of the century by suggesting that,

> when Americans learned the world was flat (Friedman, 2005), they quickly grew to believe China and India were in course to bypass America in the global economy by outSTEMming us. Funding began to flow toward all things STEM,

> and STEMmania set in. Now, nearly everyone seems somewhat familiar with the STEM acronym. (Sanders, 2008, p. 20)

Ossola has also suggested, however, that "STEM can sometimes be an overused buzzword, the negative impacts of which are felt by students who don't get a quality, well-rounded education" (Ossola, 2014). She explains that hype accompanies and obfuscates the term, stating,

> There's been so much hype around STEM education that sometimes people forget what the acronym even stands for. It's easy to lose sight of what STEM means in practice when school boards and politicians and CEOs describe its economic impact and tout its importance, oftentimes because they think it's what people want to hear. (Ossola, 2014)

Bybee has likewise suggested that the national proliferation of STEM education has outpaced attempts to think carefully about its nature and purposes. He writes, "As STEM has become one of the newest slogans in education, some critics have noted its ubiquitous and ambiguous use (e.g., Angier 2010)" (Bybee, 2013, p. 2). On the proliferated meanings of STEM education, he explains,

> As STEM education continues to expand and develop, use of acronym has been applied to advertisements, classrooms, competitions, conferences, curriculum, resources, presentations, workshops, summer experiences, and videos, to name only a few examples … The meaning or significance of STEM is not clear and distinct … In time, I have found it most useful to read or listen for the context

within which STEM is being used. In a sense, the context clarifies the meaning of STEM. (p. x)

Sanders (2008) echoes Ossola and Bybee's positions on the inconsistency of the phenomenon, explaining that STEM is an ambiguous term, especially when used in conjunction with "education". He writes that,

> Technology educators proudly lay claim to the T and E in STEM. But so, too, do Career and Technical educators, who … seem to have claimed "E" as their own. Most, even those in education, say "STEM" when they should be saying "STEM education," overlooking that STEM without education is a reference to the fields in which scientists, engineers, and mathematicians toil. Science, mathematics, and technology teachers are STEM educators working in STEM education. (Sanders, 2008, p. 20)

He notes that the National Science Foundation has, for the past 20 years, referred to the sovereign disciplines when referring to STEM. Indeed, he believes that talk of STEM education as anything other than siloed disciplines is dubious. He explains,

> some have suggested that STEM education implies interaction among the stakeholders. It doesn't. For a century, science, technology, engineering, and mathematics education have established and steadfastly defended their sovereign territories. It will take a lot more than a four-letter word to bring them together. (p. 21)

The divisive sentiment to which Sanders refers is palpable within the following statement by J. Michael Shaughnessy (2012), former President of the National Council of Teachers of Mathematics, quoted at length:

> With all due respect to our colleagues in the other disciplines, we assert that the letters in STEM are not all of equal importance in the pre-K–12 education of our students. Mathematics is paramount, mathematics is primal, mathematics is the most important STEM discipline. The other three disciplines are fundamentally dependent on the strong mathematical preparation of our students. As president of NCTM, I find myself in the position of speaking as a strong advocate for 'steM.' In our rush to secure much needed funding for our states and our schools, let us keep in mind that STEM is an advocacy position, and not a content area in and of itself. As we develop plans for STEM education initiatives, we must maintain a clear vision for the role and importance of mathematics in the education of our students. It is critical that we preserve the mathematical mean when faced with the salad bowl of STEM, lest we make a MEST of it all! (Shaughnessy, 2012)

And Madeline Patton (2013) of the Association of Teacher Educators reports that even Judith Ramaley herself, the coiner of "STEM", thought that SMET, its cacophony aside, did not engender the appropriate balance of regard for the associated disciplines. Patton explains that for Ramaley, "Switching the order of the letters to make math and science cradle engineering and technology made more sense to her" (Patton, 2013). She continues to quote Ramaley as stating, "'STEM works better because the science and math carry as

the core their applications of technology and engineering. So I concluded that on both aesthetic and conceptual grounds, STEM was better'" (Patton, 2013).

At the same time, the U.S. Department of Education (2016) recognizes STEM, STEM education, STEM workforce, and STEM teaching and learning as referring to the "subjects" or "fields" of science, technology, engineering, and math, with no apparent emphasis on the importance of one subject over any other. It also makes an explicit connection between STEM education and the fostering of specific skills it deems students will need to be competitive in a global marketplace. The Department states,

> The United States has developed as a global leader, in large part, through the genius and hard work of its scientists, engineers, and innovators. In a world that's becoming increasingly complex, where success is driven not only by *what* you know, but by what you *can do* with what you know, it's more important than ever for our youth to be equipped with the knowledge and skills to solve tough problems, gather and evaluate evidence, and make sense of information. (U.S. Department of Education, 2016)

Ossola (2014) strikes a similarly approbatory tone in her report, concluding 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). She quotes Michael Teitelbaum, "a senior research associate with the Labor and Worklife Program at Harvard Law School", as saying, "'I think that being competent in STEM fields at the end of secondary school is the modern equivalent of being literate and numerate in the 19th

century'." (Ossola, 2014). And on the question of whether or not a national emphasis on STEM education may detract from non-STEM subjects, she reports that both Teitelbaum and David Drew, "education professor at Claremont Graduate University in California", think that STEM subjects have historically not gotten enough attention (Ossola, 2014).

Drew (2011) echoes this sentiment and frames contemporary STEM education reform as a key component for American economic competitiveness, arguing that,

> To keep high-tech jobs in the United States, we must keep talented students engaged in STEM education; we must evaluate rigorously any educational reform to ensure that it works; we must create an environment for talented teachers that fosters creativity and productivity; we must increase access to affordable, high-quality undergraduate education; and we must get students excited about scientific research. (Drew, 2011, pp. 2 & 3)

He bases these injunctions upon a shift in the global economy away from industrialism and toward high-tech industries and the assertion that American students, and by extension, America's workforce, is underprepared for these modern, high-skill occupations (Drew, 2011).

At the same time, Fareed Zakaria (2015) has struck a cautionary tone regarding STEM education reform in his *Washington Post* article entitled, "Why America's Obsession with STEM Education Is Dangerous". He argues that a systemic focus on STEM areas alone is myopic and dangerous for American economic productivity, even democracy itself. He argues that crucial to economic productivity is not only technological superiority, but also creativity and innovation. He writes,

> Innovation is not simply a technical matter but rather one of understanding how people and societies work, what they need and want. America will not dominate the 21st century by making cheaper computer chips but instead by constantly reimagining how computers and other technologies interact with human beings. (Zakaria, 2015)

For Zakaria, key to workers' capacity for innovation, and the very health of the American economic infrastructure, is the provision of an education that respects not only STEM subjects, but also the liberal arts. He contends that,

> The United States has led the world in economic dynamism, innovation and entrepreneurship thanks to exactly the kind of teaching we are now told to defenestrate. A broad general education helps foster critical thinking and creativity. Exposure to a variety of fields produces synergy and cross fertilization. Yes, science and technology are crucial components of this education, but so are English and philosophy. (Zakaria, 2015)

Additionally, he argues that given the escalating computerization of American jobs, "Critical thinking is, in the end, the only way to protect American jobs" (Zakaria, 2015). And for Zakaria, critical thinking is best catalyzed in the crucible of a broad education. He states that for jobs that require skills computers still cannot quite crack, "you could not do better than to follow your passion, engage with a breadth of material in both science and the humanities, and perhaps above all, study the human condition" (Zakaria, 2015).

This brief overview of the emergent debate over STEM education indicates that the phenomenon appears to lack a fixed referent: Its nature is contextual and prismatic. In the next chapter, however, I seek to move past this cursory assessment of extant definitions and understandings of STEM education and working toward a philosophical analysis of STEM education. More specifically, I seek to explore the extent to which STEM education, and educational systems in general, can be understood as ideological and institutional outgrowths of the political economy of the United States.

References

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. Arlington, VA: National Science Teachers Association.

Dewey, J. (2012). *Democracy and education*. Middleton, DE: Simon & Brown.

Drew, D. E. (2011). *STEM the tide: Reforming science, technology, engineering, and math education in America*. Baltimore, MD: Johns Hopkins University Press.

Jolly, J. L. (2009). The National Defense Act, current STEM initiative, and the gifted. *Gifted Child Today*, *32*(2), 50-53.

Ossola, A. (December 03, 2014). Is the U.S. focusing too much on STEM? *The Atlantic*. The Atlantic Monthly Group. Retrieved from http://www.theatlantic.com/education/archive/2014/12/is-the-us-focusing-too-much-on-stem/383353/

Patton, M. (2013). ATE had role in the naming of STEM. *ATE@20*. ATE Central. Retrieved from https://atecentral.net/ate20/22917/ate-had-role-in-the-naming-of-stem

Sanders, M. (December 01, 2008). STEM, STEM Education, STEMmania. *Technology Teacher*, *68*(4), 20-26.

Shaughnessy, M. (February 2, 2012). STEM: An advocacy position, not a content area. *Summing Up*. NCTM. Retrieved from https://www.nctm.org/News-and-Calendar/Messages-from-the-President/Archive/J_-Michael-Shaughnessy/STEM_-An-Advocacy-Position,-Not-a-Content-Area/

U.S. Department of Education. (2016). Science, technology, engineering, and math: Education for global leadership. Retrieved from http://www.ed.gov/stem

Zakaria, F. (March 26, 2015). Why America's obsession with STEM education is dangerous. *The Washington Post*. Retrieved from https://www.washingtonpost.com/opinions/why-stem-wont-make-us-successful/2015/03/26/5f4604f2-d2a5-11e4-ab77-9646eea6a4c7_story.html

Chapter 3. A Critique of Education and the Status Quo

Precedents for Socio-Educational Critique

More than one century ago, John Dewey (2012 [1916]) cautioned us against establishing education as a means to prescribed ends, reasoning 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)

And he 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)

In *The Transformation of the School*, historian Lawrence Cremin (1961) situates John Dewey within the broader progressive movements of the late 19th century. He writes,

> Consider [Dewey's] early role in the progressive education movement. All about him, a cacophony of voices was demanding educational reform of every sort and variety. Businessmen and labor unions were insisting that the school assume the classical functions of apprenticeship. Settlement workers and municipal reformers were vigorously urging instruction in hygiene, domestic science, manual arts, and child care. Patriots of every stripe were calling for Americanization programs. And agrarian publicists were pressing for a new sort of training for country life that would give youngsters a sense of the joys and possibilities of farming—and incidentally, keep them from moving to the city. (pp. 116 & 117)

Dewey's contribution to this "cacophony of voices" of American progressivism was the conceptualization of the school as a "lever of social change" and thus an inextricable facet of a broader "social reformism" (pp. 116, 118, & 119). Cremin elaborates,

> Recall that Dewey's 'embryonic community' was to *reflect* the life of the larger society, thereby removing the curse he saw in traditional education, isolation from reality. But even more important, Dewey's 'embryonic community' was to *improve* the larger society by making it more 'worthy, lovely, and harmonious.' (p. 118)

He explains that in Dewey's "social reformism", "educational theory—once more in Platonic terms—becomes political theory, and the educator is inevitably cast into the

struggle for social reform", and that, "The school is recalled from isolation to the center of the struggle for a better life" (pp. 119 & 120).

Nearly one century ago, George Counts (1978 [1932]) echoed Dewey's concerns about education being illiberal, arguing 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 when he wrote,

> 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)

He implicated capitalism more generally in his analysis and posed incisive questions about the role of the school in this order, enjoining 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).

Jean Anyon (1980) offered one such institutional critique in her groundbreaking work on the relationship between schools in the United States and social class structure. In "Social Class and the Hidden Curriculum of Work", she revealed the extent to which state-capitalism had rendered schools into sites for class reproduction by the early 1980s.

She explains that although researchers had up to that point collected evidence to help explain the interrelationships between schooling and capitalism in Europe and North America, "there has been little or no attempt to investigate these ideas empirically in elementary or secondary schools and classrooms in this country" (Anyon, 1980, p. 67).

She proposes her study as an attempt to fill in the gap in this literature and outlines three specific dimensions of social class integral for understanding the complex ways in which public schools may reify existent class divisions. All three dimensions of social class have to do with the relations that individuals have with the production process in a capitalist society, the first of which she calls "ownership relations" (p. 68). This dimension of social class refers to the relationships that individuals have to two forms of capital in society: physical and symbolic. On the former, she writes,

> In a capitalist society, a person has a relation to the system of private ownership of capital. Capital is usually thought of as being derived from physical property. In this sense capital is property which is used to produce profit, interest, or rent—that is, more capital. Physical capital may be derived from money, stocks, machines, land, or the labor of workers (whose labor, for instance, may produce products that are sold by others for profit). (p. 69)

She continues to explain that the latter form of capital, symbolic capital, "can be the socially legitimated knowledge of how the production process works, its financial, managerial, technical, and other 'secrets.'" (p. 69). Moreover, symbolic capital can take the form of "socially legitimated skills—cognitive (e.g., analytical), linguistic, or technical skills that provide the ability to, say, produce the dominant scientific, artistic,

and other culture, or to manage the systems of industrial and cultural production" (p. 69). She adds that the mastery and wielding of symbolic capital may yield power, as well as actual, physical capital: "Skillful application of symbolic capital", she writes, "may yield social and cultural power, and perhaps physical capital as well" (p. 69).

The second dimension of social class is "relationships between people" (p. 70). This dimension of social class refers to the relationships that workers have "to authority and control at work and in society" (p. 70). The extent to which workers have authority over their colleagues and control over the process of production varies in accordance with social class status. For example, she explains that the majority of working-class jobs have "no built-in mechanism by which the worker can control the content, process, or speed of work" (p. 70). Instead, bureaucracies invest the actual authority to make decisions in supervisors and managers, workers who belong to the "white-collar working-class" and middle-class (p. 70). At the same time, she explains that the professionals belonging to the upper-middle-class have "an increased amount of autonomy regarding work" (p. 70). And at the zenith of class hierarchy, capitalists enjoy "direct control of the entire enterprise" (p. 70). By this, she means that capitalists have the authority to decide how to invest and allocate enterprises' money and profits (Anyon, 1980).

And the third dimension of social class is "relationships between people and their work" (p. 70). This dimension of social class refers to "the relationship between that person and his or her own productive activity—the type of activity that constitutes his or her work" (p. 70). Similar to workers' levels of authority over colleagues and control over production processes being based upon social class status, workers also experience

varying relationships to their work in accordance with class status. For example, she explains that workers who belong to the working-class often engage in routinized, mechanized, and manual work. They do not have control over the content of their work, and the work itself is ultimately a small part of the entire production process of an industry. Workers in the middle-class, however, increasingly encounter opportunities for conceptualization in their work, while upper-middle-class professionals regularly enjoy creative work. She suggests that workers in the capitalist class partake in strictly conceptualized work, "(e.g., planning and laying-out) that has as its object management and control of the enterprise" (p. 70).

For Anyon, at the crux of this discussion of social class status is the process by which the individual acquires it and the extent to which schooling contributes to its constellation. She writes that,

> Social class is perceived as a complex of social relations that one develops as one grows up—as one acquires and develops certain bodies of knowledge, skills, abilities, and traits, and as one has contact and opportunity in the world. In sum, social class describes relationships which we as adults have developed, may attempt to maintain, and in which we participate every working day. These relationships in a real sense define our material ties to the world. An important concern here is whether these relationships are developing in children in schools within particular social class contexts. (p. 71)

In order to explore this concern, Anyon and her team visited five public, primary schools, and more specifically, five, fifth grade classrooms, in New Jersey and interviewed

students, teachers, educational staff, principals, and administrative staff, observed classroom activity, and analyzed curricular and other educational artifacts. A key facet of their study was the fact that the five schools were located within four different socio-economic environments, determined in part according to the social-class statuses of the students' parents. The first two schools were located in a working-class context, the third was located in a middle-class context, the fourth was located in an upper-middle-class context, and the fifth was located in an elite or capitalist class context.

They discovered that the schools functioned on a daily basis in ways commensurate with the particular socio-economic contexts in which they were located, exhibiting class-specific relationships between not only students and teachers, but also students and their educational activities, or work. They denoted the first two schools as "Working-Class Schools", the second school as a "Middle-Class School", the fourth school as an "Affluent Professional School", and the fifth school as an "Executive Elite School" (Anyon, 1980).

In the Working-Class Schools, teachers controlled the space and communicated to students via directives. Teachers' claims to authority were so strong that they ignored the bells for changing classrooms. They assigned students routinized work that had to be completed to their specifications. Teachers' expectations for students were limited, captured in their neglecting to teach students advanced punctuation. In the Middle-Class School, teachers communicated to students with less stringency. The real authority in the middle-class school laid within the textbook and the school itself. Students' work centered on attaining high grades in order to proceed to more propitious rungs on

academic and occupational ladders. In the "Affluent Professional School", teachers communicated to students with respect. Students enjoyed considerable freedom in the school, being able to visit the library without permission if they so desired. Students' work centered on creative output and self-expression. Moreover, of the schools visited, this was the only school that prevented Anyon and her colleagues from taking students' work as artifacts. And finally, in the Executive Elite School, teachers comported with students as guides and communicated to them with respect. Students' work centered on rigorous analyses of academic topics and solving problems through innovative approaches (Anyon, 1980).

What these findings and patterns ultimately allowed Anyon and her colleagues to posit was that schools and the experiences within them play a pivotal role in perpetuating class divisions in society. She calls for her work and future research on these relationships to be elucidatory in the attempt to understand how institutions of learning can be complicit in socio-economic stratification within a capitalist society.

Giroux's Critique of the Status Quo

Recently, Henry Giroux (2013) has argued that corporate and allied political elites, including both Republicans and Democrats, have accomplished nothing short of a takeover of the "social state" (Giroux, 2013). He argues that elites are promoting neoliberalism, or what should more accurately be referred to as "casino capitalism," "in which Wall Street creates an economy focused on speculative, short-term investments 'designed to make a killing rather than expanding the productive base of the economy.'"

(Giroux, 2013). He expands upon the deleterious effects of neoliberalism as a predatory form of capitalist ideology:

> Under casino capitalism, the spaces, institutions, and values that constitute the public are now surrendered to powerful financial forces and viewed simply as another market to be commodified, privatized, and surrendered to the demands of capital. With market-driven zealots in charge of both parties, politics becomes an extension of war, and greed and self-interest trump any concern for the well-being of others. (Giroux, 2013)

He argues that neoliberalism, or casino capitalism, enacts violence on institutions like schools by surrendering them, as well as "the spaces … and values that constitute the public", "to powerful financial forces", seeing them "simply as another market to be commodified, privatized, and surrendered to the demands of capital" (Giroux, 2013). Neoliberalism is thus a potent socio-economic force responsible for "destroying education systems, producing atomized subjects, and loosening individuals from any sense of social responsibility" and thus displaces the values of sociality with "a slow embrace of social Darwinism, state terrorism, and the mentality of war" (Giroux, 2013).

We are thus experiencing "a full-scale attack on the social contract, the welfare state, economic equality, and any viable vestige of moral and social responsibility" (Giroux, 2013). This emergent neoliberalized state also targets specific concepts and groups. He explains that, "science, immigrants, women, the elderly, the poor, people of color, and youth" are under assault, including those who simply seek reason, freedom, and doubt, or "all those who bear the sins of the Enlightenment" (Giroux, 2013). Given

Giroux's allusions to the social and welfare state, how can we think more deeply about the nature of the state and its constitutive social institutions?

The State of the State

Seumas Miller (2014) refers to the state as the "nation-state" and writes that the "contemporary liberal democratic nation-state" can be imagined as being "comprised of a number of semi-autonomous public and private institutions functioning in the context of the meta-institution of government" (Miller, 2014, p. 14). The state thus both contains and is comprised by various social institutions, one of which is the "meta-institution" of the government: He explains that,

> Social institutions are often organisations (Scott 2001). Moreover, many institutions are *systems* of organizations. For example, capitalism is a particular kind of economic institution, and in modern times capitalism consists in large part in specific organisational forms—including multinational corporations—organised into a system. Further, some institutions are meta-institutions; they are institutions (organisations) that organise other institutions (including systems of organisations). For example, governments are meta-institutions. The institutional end or function of a government consists in large part in organising other institutions (both individually and collectively); thus governments regulate and coordinate economic systems, educational institutions, police and military organisations and so on largely by way of (enforceable) legislation. (p. 4)

Miller suggests that political conservatism occurs when "the 'well-being' of the society as a whole is sometimes identified with the stability and continuation of the society as it

is", and that political authoritarianism can emerge from political conservatism "when society is identified with the system of institutions that constitute the nation-state and the meta-institution of the nation-state—the government—is assigned absolute authority in relation to all other institutions" (p. 12). He explains that political authoritarianism thus stands in marked contrast to political liberalism due to the latter's enjoinment of the separation of powers between the branches of government (Miller, 2014).

Chandran Kukathas (2014) argues that the concept of the state is remarkably complex, but that it also exhibits essential features. For example, he posits that the state is one form of "political association" and that the task of defining this entity "is to account for the kind of political association it is, and to describe its relation to other forms of human association, and to other kinds of human collectivity more generally" (Kukathas, 2014, p. 357). The state thus can, and cannot, be described in certain ways.

For instance, he stipulates that, "The state should not be viewed as a form of association that subsumes or subordinates all others," and that, "The state is not an entity whose interests map closely onto the interests of the groups and individuals that fall under its authority" (p. 357). Moreover, he writes that, "The state is not there to secure people's deepest interests, and it does not serve to unify them, reconcile them with one another, bring their competing interests into harmony, or realise any important good – such as justice, freedom, or peace" (p. 357).

At the same time, he explains that the state "has interests of its own", and "though … of human construction", is in some ways "an alien power … not within human control" (p. 357). But he also suggests that individuals can "harness" the power of the

state “from time to time”, but that this “will serve the interests of some, not the interests of all,” and that, “The state is thus an institution through which individuals and groups seek to exercise power (though it is not the only such institution); but it is also an institution that exercises power over individuals and groups” (p. 357). He argues that, in the end, the state is actually an abstract concept, lacking materiality, an ascribed space, and embodiment within either a person or people; but because it emerges from society and intersubjective conditions, it also “has a life of its own”, though not an “entirely autonomous” one (pp. 357 & 358).

States are distinguishable from each other in the sense that each has “independent structure of political authority” as well as “attachment to separate physical territories” (p. 358). The state can also possess certain entities, like nations and governments, with the caveats that, “A state is not a *nation,* or a *people*, though it may contain a single nation, parts of different nations, or a number of entire nations,” and that, “A state will have a *government*, but the state is not simply a government, for there exist many more governments than there are states” (p. 358). He explains further that governments precede states; governments can also exist without states (he cites the case of the Palestinian Authority), and states can “exist with many governments” and even without governments (he cites the cases of Somalia, Iraq, and Japan during specific periods in the 20th century) (p. 360).

Fundamentally, however, as a political association, the state is a collectivity of agents constituted by a structure of authority, “joined for the purpose for carrying out some action or actions”, and thus itself has the capacity for agency, unlike those entities

that are not associations, like "collectivities of persons, such as classes or crowds or neighborhoods or categories (like bachelors or smokers or amputees)" (p. 358). Moreover, he explains that, "The most important aspect of the state that makes it a distinctive and new form of political association is its most abstract quality: it is a *corporate* entity" (p. 358). By this, he means that as a "modern form of political construction" and "polity", the state can incorporate entities, but that it is also not able to be "incorporated into any other political associations" (p. 358).

Additionally, as a corporate entity, a state can be considered "a legal person", not only with "the capacity to act but also a liability to be held responsible" (p. 360). As a corporate entity with the rights of a legal person, therefore, a state can raise revenue and acquire property, but "being an abstract entity, cannot enjoy the use of its property – only redistribute it among the agents through whom it exercises power and among others whom those agents are able, or obliged, to favour" (p. 361). He notes that, "The state is not the only political corporation capable of raising revenue and acquiring property, through it will generally be the most voracious in its appetite" (p. 361). Although a state as a "supreme corporate entity" cannot be incorporated by another entity (such as a supranational institution) lest it cease being a state, he makes the caveat that the state can "be subordinate to other powers (such as another state or an empire)" (p. 358). He expands upon the forms this subordination can take by writing that, "States might also be parts of *empires*, or operate under the *sphere of influence* of another more powerful state" (p. 362).

Giroux's critique of the state effectively challenges Miller's relatively textbook depiction of the "contemporary liberal democratic nation-state" as having a government that functions practically as a social meta-institution that effectively regulates capitalism's constitutive "forms", or the systemic organizations (or institutions) known as multinational corporations (Miller, 2014, pp. 4 & 14). It also challenges Kukathas' comparatively tepid assertions that individuals can "harness" the power of the state "from time to time" and that this "will serve the interests of some, not the interests of all" (Kukathas, 2014, p. 357). Instead, Giroux's analysis holds that the perverse transmogrification of government from an instrument of the public good to an instrument of private power is endemic, and that, "Matters of politics, power, ideology, governance, economics, and policy now translate unapologetically into a system of divestment in those public spheres that traditionally provided the minimal conditions for social justice, dissent, and democratic expression" (Giroux, 2013). "It is clear", he warns, "that an emergent authoritarianism haunts a defanged democracy now shaped and structured largely by corporations" (Giroux, 2013).

Relatedly, philosopher Michael Sandel (MSNBC, 2012) has pointed to one form of corporate incursion into government being wealthy lobbyists' practice of hiring line-standing companies for securing access to and representation in congressional hearings on Capitol Hill. He argues that although the practice is legal, it is also corrupt. It is corrupt primarily in the sense that it privatizes, and thus perverts and "degrades", the aims of Congress as a social institution charged with pursuing the public good. He writes that,

> To corrupt a good or social practice is to degrade it, to treat it according to a lower mode of valuation than is appropriate to it. Charging admission to congressional hearings is a form of corruption in this sense. It treats Congress as if it were a business rather than an institution of representative government. (MSNBC, 2012)

The American State as Imperialist System

Late political scientist Sheldon Wolin's (2008) examination of the American socio-political, economic, and educational status quo deepens the foregoing critical analysis of our current social institutions, practices, and the state itself. With his invocation of concepts like *Superpower*, *inverted totalitarianism*, and *managed democracy*, he elucidates the macrocosmic socio-economic and political forces that affect us in our everyday lives as citizens, consumers, and learners.

At the core of his analysis is the brow-raising contention that the United States is not, in fact, a democratic polity, but is instead an antidemocratic empire. During an interview with CBS News journalist Bill Moyers three decades ago, and two decades prior to publishing *Democracy, Inc.*, Wolin (1988) warned that all of the primary institutions in the United States, including "large-scale educational institutions, … institutions of government, major institutions of media and communication, major institutions of a recognizably economic kind … and … large cultural institutions", were "antidemocratic", meaning hierarchical in nature and exclusionary or restricted only to an elite few (Wolin, 1988).

Two decades later in *Democracy, Inc.*, he (2008) argues that the Founders never intended for the United States to become a democracy and returns us to their

deliberations to posit that what they envisioned for the United States was a system of government that actively curtailed the putative dangers of popular democracy: a republican, versus a truly democratic, system. He explains that within a republic, only a small group of elites, "the Few", self-invest political power, leaving the rest of the citizenry, "the Many", coerced into thinking that they have political power via access to the voting booth. In reality, the potency of popular suffrage, and thus political democracy itself, 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 its very inception, therefore, the United States has been guided by elites who 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, however, that there have been 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. He describes this period in the following passage, quoted at length:

> At the same time that the war halted the momentum of political and social democracy, it enlarged the scale of an increasingly open cohabitation between the corporation and the state. That partnership became ever closer during the era of the Cold War (1947–93). Corporate economic power became the basis of power on which the state relied, as its own ambitions, like those of giant corporations, became more expansive, more global, and, at intervals, more bellicose. Together the state and corporation became the main sponsors and coordinators of the powers represented by science and technology. The result is an unprecedented combination of powers distinguished by their totalizing tendencies, powers that not only challenge established boundaries—political, moral, intellectual, and economic—but whose very nature it is to challenge those boundaries continually, even to challenge the limits of the earth itself. (Wolin, 2008, p. xv)

The New Deal and its socio-economic egalitarianism lost support from even its most kindred champions: liberals. He writes, "Neoliberalism emerged as the New Deal's residuary legatee and found its icon in JFK," adding 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 that it was due to 1950s McCarthyism, however, that "New Deal values of social democracy were effectively purged from the national power imaginary", writing,

> 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 state and corporate power. 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)

Furthermore, he explains that this corporate-state amalgam henceforth nourished antidemocratic, imperialist tendencies within the country's political system:

> The defender of the free world needed the power of the globalizing, expanding corporation, not an economy hampered by 'trust-busting.' Moreover, since the enemy was rabidly anticapitalist, every measure that strengthened capitalism was a blow against the enemy. Once the battle lines between communism and the 'free society' were drawn, the economy became untouchable for purposes other than 'strengthening' capitalism. The ultimate merger would be between capitalism and democracy. Once the identity and security of democracy were successfully identified with the Cold War and with the methods for waging it, the stage was set for the intimidation of most politics left of right. (p. 34)

With its founding elites having inculcated within the United States' social, political, and juridical DNA the dictates and practices of a republican, and not a democratic, system of

governance, the country would thus evolve into a corporate-state bent on defending itself at all costs from communist and foreign adversaries by amalgamating capitalism with democracy and embracing science and technology as well as the expanded military with which they came.

In order to differentiate between how the United States expresses its imperialistic power globally versus domestically, Wolin uses the term "Superpower" to capture the United States empire's outward projection of power for foreign domination and expansionism. He proposes 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). American inverted totalitarianism thus represents "the *political* coming of age of corporate power and the *political* demobilization of the citizenry" (p. x).

He is also careful to distinguish between contemporary American inverted totalitarianism and preceding manifestations of totalitarianism, however, namely German and Italian fascisms, the latter of which "were powered by revolutionary movements whose aim was not only to capture, reconstitute, and monopolize state power but also to gain control over the economy", with the ultimate aim "to reconstruct, then mobilize society" (p. ix). American inverted totalitarianism differs from these movements, on the other hand, partially because it "is only in part a state-centered phenomenon" (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 poses a dire threat to public institutions writ large and to systems of public education more specifically. 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", thereby underscoring the power that corporate elites have over the modern state apparatus (p. 136). In the end, if we take Wolin's analysis seriously, we must consider the reality that the United States stands as a 21st century imperialist system helmed by corporate elites who seek power and profit through foreign domination via Superpower and domestic servitude via inverted totalitarianism and managed democracy.

Imperial Neoliberalism as Governing Political Rationality

Wendy Brown (2015), Wolin's former student, furthers our understanding of the effects of state-neoliberalism upon individual experience and citizenship. 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, resonant with Wolin's macrocosmic analysis of the corporate-state amalgam, 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 would- and 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).

By way of Foucault, Brown accounts for the experience of the individual by understanding it as a subject constructed by various socio-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, whereas the term "homo oeconomicus" roughly denotes a subject constructed in accordance with the norms and dictates of an economic system. She posits 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 goes on to briefly chart the transmogrification of homo oeconomicus in the past two centuries, explaining that,

> Two hundred years ago, the figure famously drawn by Adam Smith was that of a merchant or trader who relentlessly pursued his own interests through exchange. One hundred years ago, the principle of *homo oeconomicus* was reconceived by

> Jeremy Bentham as avoidance of pain and pursuit of pleasure, of endless cost-benefit calculations. (p. 32)

And she argues that up to the mid-1980s, what she claims to be the dawn of the contemporary neoliberal era, the subject of the Global North (as opposed to the subject of the Global South, which, she explains, found itself at the whim of North-imposed neoliberal experiments as early as the 1970s) was homo oeconomicus, "still oriented by interest and profit seeking", though different than its forebears in the sense that it "now entrepreneurialized itself at every turn and was formulated as human capital" (pp. 32 & 47).

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 exaggerating: 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). The extent to which the contemporary subject has been

constructed in accordance with the norms and dictates of neoliberal reason could thus be considered alarmingly total. She writes,

> To speak of the relentless and ubiquitous economization of all features of life by neoliberalism is thus not to claim that neoliberalism literally *marketizes* all spheres, even as such marketization is certainly one important effect of neoliberalism. Rather, the point is that neoliberal rationality disseminates the *model of the market* to all domains and activities—even where money is not at issue—and configures human beings exclusively as market actors, always, only, and everywhere as *homo oeconomicus*. (p. 31)

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). She states,

> As neoliberal rationality remakes the human being as human capital, an earlier rendering of *homo oeconomicus* as an interest maximizer gives way to a formulation of the subject as both a member of a firm and as itself a firm, and in both cases as appropriately conducted by the governance practices appropriate to firms. (p. 34)

Contemporary homo oeconomicus as itself a self-investing firm thus conceives of present experiences as investment opportunities for future status. She writes,

> Whether through social media 'followers,' 'likes,' and 'retweets,' through rankings and ratings for every activity and domain, or through directly monetized practices, the pursuit of education, training, leisure, reproduction, consumption,

> and more are increasingly configured as strategic decisions and practices related to enhancing the self's future value. (p. 34)

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 regime of the neoliberalized state, human capitals seek investment opportunities to secure nothing less than survival itself, as the evisceration of social safety nets within an era of intensified competition leaves human capitals with no room for error. She explains that,

> both persons and states are construed on the model of the contemporary firm, both persons and states are expected to comport themselves in ways that maximize their capital value in the present and enhance their future value … Any regime pursuing another course faces fiscal crises, downgraded credit, currency or bond ratings, and lost legitimacy at the least, bankruptcy and dissolution at the extreme. Likewise, any individual who veers into other pursuits risks impoverishment and a loss of esteem and creditworthiness at the least, survival at the extreme. (p. 22)

This regime of competitiveness and survival has also begun to quash educational institutions as spaces in which learners become cultivated into an informed citizenry. She explains that,

> Citizens cannot rule themselves, even if that means only thoughtfully choosing representatives or voting on referenda, let alone engaging in more direct practices of shared rule, without understanding the powers and problems they are engaging. Providing tools for such understanding has been the premise of public secondary and higher education in the West over the past two centuries and has especially

> undergirded cultivation of a liberal arts curriculum in American universities. (pp. 175 & 176)

Educational institutions have thus been transmogrified into spaces in which human capitals compete 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 category of subjectification vital to the maintenance of liberal democracy itself.

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 has existed and could still exist under forms of governance other than liberal democracy.

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 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 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.

Wolin's analysis of the United States as an imperialist system and Brown's formulation of citizens as consumers, and more abstractly, homo oeconomicus, are startling and revelatory. In an interpretive inversion, if Wolin's ideas are vital for understanding the nature of the state and how the state imposes itself upon the experience

of the citizen, Brown's ideas are vital for understanding the experience of the citizen and how it relates to the nature of the state. Their conclusions pose an ethical injunction: to consider the consequences of living in and supporting a neoliberalized 21st century empire. They also open up new avenues for research into the various dimensions of neoliberalism as a governing form of political rationality within an imperialist American corporate-state, including the extent to which education, a vital concern for both Wolin and Brown, relates to both. The following chapter will explore the role STEM education in particular plays within this milieu.

References

Anyon, J. (1980). Social class and the hidden curriculum of work. *Journal of Education, 162*(1), 67-92.

Brown, W. (2015). *Undoing the demos: Neoliberalism's stealth revolution*. New York, NY: Zone Books.

Counts, G. S. (1978). *Dare the school build a new social order?*. Carbondale, IL: Southern Illinois University Press.

Cremin, L. A. (1961). *The transformation of the school: Progressivism in American education, 1876-1957 / Lawrence A. Cremin*. New York, NY: Alfred A. Knopf.

Dewey, J. (2012). *Democracy and education*. Middleton, DE: Simon & Brown.

Giroux, H. A. (2013). Challenging casino capitalism and authoritarian politics in the age of disposability. *Monthly Review Press*. Retrieved from http://www.truth-out.org/news/item/17176-henry-a-giroux-americas-education-deficit

Kukathas, C. (2014). A definition of the state. *University of Queensland Law Journal*, *33*(2), 357-366.

Miller, S. (2014). Social institutions. *The Stanford Encyclopedia of Philosophy*. Retrieved from https://plato.stanford.edu/archives/win2014/entries/social-institutions/

MSNBC. (2012). An excerpt from Michael Sandel's "*What money can't buy*". NBC Universal. Retrieved from http://www.msnbc.com/morning-joe/excerpt-michael-sandels-book

Wolin, S. S. (2008). *Democracy incorporated: Managed democracy and the specter of inverted totalitarianism*. Princeton, NJ: Princeton University Press.

Wolin, S. S. (1988). Sheldon Wolin: The state of democracy. *Moyers & Company*. Public Square Media, Inc.

Chapter 4. STEM Education and the Status Quo

Chesky and Wolfmeyer's Critique of STEM Education

Nataly Chesky and Mark Wolfmeyer (2015) evoke concepts consistent with the foregoing theoretical critique in their critical investigation of 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 an 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 a 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 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 presume that research and critique of STEM education policy will enhance the objectives of this policy and thus the practice of STEM education itself. Indeed, they argue that,

> the relationship between assumptions about STEM content (ontology), claims on best practices of teaching STEM content (epistemology), and aims of STEM policy reforms (axiology), all relate to one another and ought to be investigated for how this relationship is discussed and presented in public policy texts. (p. 10)

To them, research of STEM policy is crucial for offering novel conceptions of STEM education policy reform and even new methods by which STEM educators, who are "navigating the educational policy landscape", could teach their subjects (p. 11).

They ultimately argue, however, that the discourse appears to be influenced by political and economic, or corporate, elites who utilize it as an instrument of power and profit that effectively dominates and oppresses students and educational institutions. What results is a discourse that construes subject matter as unquestionable, teaching and learning as traditional, and educational aims as utilitarian. In other words, it frames content (ontology) as absolutist, pedagogy (epistemology) as authoritarian, and

educational aims (axiology) as instrumental to the maintenance of corporate and state power (Chesky & Wolfmeyer, 2015).

They provide empirical evidence in support of this conceptualization of STEM education as a discourse emergent from and aligned with corporate-statist aims by depicting the proliferation of the latent ontological, epistemological, and axiological assumptions within the STEM educational policy literature via a coding analysis of recent STEM education policy literature. In doing so, they have been able to illuminate facets of the very dominant culture that gives rise to this policy literature. In short, their project is culturally revelatory.

In their section discussing the utilization of Alain Badiou's thinking for uncovering revolutionary potential within the STEM discourse and reimagining traditional STEM concepts, they comment on the need for a shift in contemporary cultural mores:

> Thus, if we seek a new definition of number, an alternative conception of mathematics, and a new method of teaching it, certain societal norms and values may change as well. For example, we would no longer value economic status as depicted by our bank accounts and earning statements to justify out worth; instead we may value how close our friendships and relationships are and what positive influences we have made. Simply, this is a question of how we come to perceive reality, as either quantifiable discrete parts or as relational interconnected points. (p. 49)

Here, they are contending that a cultural shift away from an existent dominant culture needs to occur in our society. Their coding analysis of the contemporary policy literature on STEM education is thus an attempt to reveal and understand this dominant culture.

Their position on the nature of policy documents "as social texts, which 'emerge out of, but also produce, particular policy discourses'" is also strikingly consistent with the Vega Model (Chesky and Wolfmeyer, 2015, p. 52). In fact, they invoke terms consistent with the model when they explain how policy literature is both a result of and a vehicle for culture, though they conflate the terms the model ascribes separately to culture (values and norms) and individuals (beliefs). They explain,

> Policy documents are not static entities that exist outside the socio-political world out of which they arise. Rather, they are influenced by and created in socio-political contexts that are negotiated and agreed by the people within a society that hold a power position which enables them to disseminate their own values, norms, and beliefs onto the masses. (p. 51)

They continue to explain how and why policy analysis is important for understanding culture more broadly, writing that,

> Understanding policy documents is the way researchers can study the normative assumptions a particular society has on certain issues and disciplines. In the case of this study, views on what STEM education ought to serve, how it ought to proceed, and what it ought to encompass are all societally held normative assumptions. These assumptions are found in policy documents, since these documents help shape and often reflect the norms held by groups that have the

> authoritative power to make decisions about what is best for citizens and their children when it comes to their education. (pp. 51 & 52)

Their investigation of STEM educational thus employs an "extraction" of STEM education policy documents as social artifacts from the multifaceted process of dominant cultural reproduction that has produced them, thus shedding light on the nature of dominant culture itself. Figure 1 depicts the use of an amended version of scholar Flavio Vega's (Martin, 1992) "Wholistic Model for the Study of Social Policy on Race, Sex, and Class Diversity in Education", elaborated upon in Appendix A., to account for Chesky and Wolfmeyer's analysis:

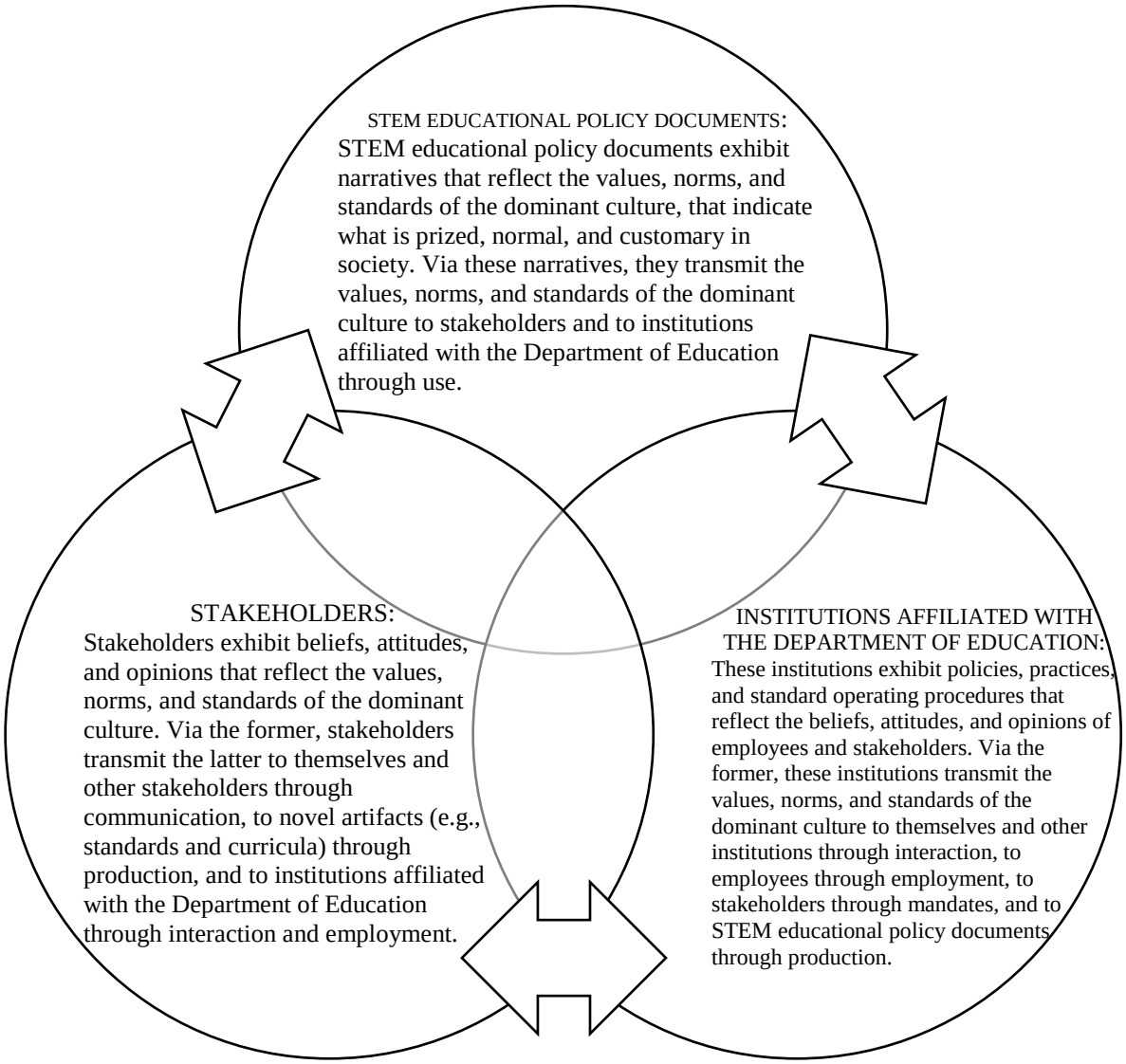

Figure 1 Using an Amended Version of Flavio Vega's (Martin, 1992) Wholistic Model for the Study of Social Policy on Race, Sex, and Class Diversity in Education to Depict the Transmission of Dominant Culture Via STEM Educational Policy Documents

They explain further how their examination of policy documents, and the dominant culture underlying them, can inform broader social and political analyses:

> Extrapolating the norms a society has on a particular issue is a difficult undertaking. However, analysis of public policy documents provides a method by

> which researchers can view the rhetoric and discourse surrounding highly political societal issues of great importance, such as STEM education in the 21st century … Analysis of policy documents has the potential to expand the research done in policy studies beyond simple implementation advocacy or critique, but to broader areas of discussion about the very purposes of educational policy and how or why such purposes can be used. (p. 52)

Their analysis thus indicates that social institutions like educational agencies produce social artifacts such as policy documents that, when analyzed, can elucidate the nature of the dominant culture that gives rise to them.

One of the most striking aspects of Chesky and Wolfmeyer's investigation is, therefore, their contention that, compared to educational policy writ large, it is the STEM educational policy discourse in particular that exudes the strongest expression of neoliberal rhetoric and that, as a result, it stands as one of the most oppressive and revolutionary educational discourses in existence today. Though bold, their assertion tends to square with how we hear political figures on the right talk about the importance of STEM education for the country's economic future.

For instance, Wisconsin Governor Scott Walker, an advocate for the privatization of public education, has championed the implementation of STEM educational programs in his state. In 2014, for example, he proclaimed the week of March 10th to the 15th of that year to be "the Celebration of STEM Education Week in Wisconsin" (State of Wisconsin Department of Workforce Development, 2014, p. 30). In its news release from that month, Wisconsin's Department of Workforce Development quotes Walker as

stating that, "'STEM represents major economic clusters and development in Wisconsin, and experts believe STEM-related job openings will more than double between 2008 and 2018,'" and that, "'Given both the opportunities and the need by employers to fill their labor market needs, we must do everything we can now to engage and motivate students to explore science, technology and other high tech fields [sic] subject areas and related career pathways'" (p. 30). Given that Walker attacked the Wisconsin Idea's injunctions for "public service" and "the search for truth" less than one year later, an act that betrays a neoliberal agenda that seeks to supplant liberal arts-based public educational institutions with private, for-profit, industry-centered educational initiatives, there appears to be a strong connection between the neoliberal assault on public education and policy moves designed to implement STEM educational initiatives (Wong, 2015; Johnson, 2015).

But would Chesky and Wolfmeyer's critique track for analyses of other extant cases for STEM education? Would their assertion that the STEM educational policy discourse is essentially the apotheosis of neoliberal governmentality hold up? Could we draw upon the Vega model and frame extant cases for STEM education as social artifacts within the process of dominant culture that convey norms, values, and standards to society, either consistent with or contradictory to hegemonic norms? In the following pages, I will review two notable cases for STEM education, Rodger Bybee's (2013) *The Case for STEM Education: Challenges and Opportunities* and Andrew Hacker's (2010) *The Math Myth: And other STEM Delusions*. I have chosen these two authors as main interlocutors for this comparative analysis because their works represent excellent

examples of two distinct positions on STEM education. In this review, therefore, I will treat both documents as social artifacts within dominant culture, paying attention to the norms, values, and standards they exude, as well as the extent to which they either ideologically complement or conflict with each other.

Bybee's Case for STEM Education

Rodger Bybee's (2013) *The Case for STEM Education: Challenges and Opportunities,* published by the National Science Teachers Association, is a comprehensive case for STEM education. An advisor to Congress on STEM education, Bybee presents his text as a guide for policymakers, administrators, academics, and educators to clarify what STEM education could mean and entail in future policy, programs, and practice. He writes, "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). Ultimately, Bybee's text deserves careful consideration because it offers a carefully researched, methodical, practical, and enactable vision for STEM education.

What is immediately noteworthy about Bybee's work, though, 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). He also elaborates upon what he means by "STEM literacy" by suggesting that it is a "broader category, which applies to everyone" and

> which refers to an individual's
>
> (a) knowledge, attitudes, and skills to identify questions and problems in life situations, explain the natural and designed world, and draw evidence-based conclusions about STEM-related issues;
>
> (b) understanding of the characteristic features of STEM disciplines as forms of human knowledge, inquiry, and design;
>
> (c) awareness of how STEM disciplines shape our material, intellectual, and cultural environments; and
>
> (d) willingness to engage in STEM-related issues and with the ideas of science, technology, engineering, and mathematics as a constructive, concerned, and reflective citizen. (pp. x & xi)

"This defines STEM literacy," he writes, "a goal of STEM education. This goal has to be translated into policies, education programs, and, finally, the concrete practices of teaching" (p. xi). But given his recognition of the prismatic nature of STEM education, why does he offer a prescription for STEM education via something specific like STEM literacy?

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)

His assertion that education should have an intimate relationship to students' lived experiences also feels Deweyian, and 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 argues, therefore, that the cultivation of STEM literacy for everyone is a concrete purpose for STEM education, regardless of programmatic and conceptual variability. His first stated goal in the introduction, (1) a STEM-literate society, captures this purpose.

On the other hand, he contends that there are other "challenges and opportunities" that STEM education can address through the cultivation of STEM literacy, alluded to in aims (2) and (3). 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,

> 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).

He argues that to meet these challenges, "the United States must address the reform of STEM education" (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). It is thus toward the fulfillment of these broader aims that his view of STEM education moves beyond the cultivation of the individual and their literacy, and perhaps their relationship to their community, and toward economic, national, and global pursuits.

Bybee thus 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 civil society, and economic competitiveness and national security for the country. Due to these advantages, he

suggests we move from STEM education as a mere slogan to STEM education as a reality, perhaps via a "goal-directed movement", pronouncing,

> 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's case for implementing STEM educational programs nationally thus provides a number of thoughtful propositions to consider. It acknowledges the importance of students' interests in the process of learning, thereby potentially preventing STEM educational learning experiences from becoming overly technical and transactional and embedding learning activities within problems or pursuits that are meaningful and practically valuable to students. This is a major selling point for adopting Bybee's vision for STEM education.

It also addresses the challenge of preparing new generations for a fast-moving and highly technological marketplace. Regardless of one's theoretical proclivities, the task of providing students opportunities for gainful and rewarding employment is an important one. Equally important is ensuring that students of lower socio-economic status and students of color have opportunities for economic stability and mobility. It seems Bybee's case could provide instructive ways for thinking about this priority. Moreover, Bybee is right to point out that nations must face "grand" 21st century challenges. There is no doubt, for example, that STEM education will and must play a crucial role in such

global challenges as disease prevention and eradication and the mitigation of climate change. Literacy in the STEM fields will certainly be at the heart of the cultivation of new generations of thought-leaders, scientists, and activists.

At the same time, could Bybee's application of STEM literacy acquisition to the wide-ranging problems it identifies contain tensions and contradictions? Are there reasons we should be critical of a case that posits STEM literacy as a means for buttressing American socio-economic and militaristic power in today's so-called "Sputnik moment" (p. 30)? And to what extent should a STEM educational paradigm account for aims that are not necessarily beholden to the fortification of a nation's economic and political security, such as social justice aims like the mitigation of systemic racism, sexism, and classism?

Hacker's Case for STEM Education

Another significant case for STEM education is Andrew Hacker's (2016) recent, *The Math Myth: And other STEM Delusions*. His work is important because it offers a sober critique of the prevailing sentiments about STEM education as a panacea for our country's educational and socio-economic woes. It attempts to dispel putative myths about the centrality of STEM education to a good education and a competitive workforce.

More specifically, Hacker argues that STEM education and its "hegemony" is incommensurate 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 offers instead a Dewey-inspired account of contemporary education and STEM education in particular, in which he advocates for the importance of fundamental skills and a reconceptualization of “excellence”.

Hacker is also trenchantly critical of “tracking” or “ability grouping”, accusing current mathematics programs of tracking the most, seeing as schools generally do not have slow and fast tracks in social studies or biology, and, therefore, segregating students usually based upon their backgrounds (p. 152). He writes, “Ostensibly, the apartheid is solely for academic reasons, but the fallout can be enduring” (p. 152). He also identifies an international economic race as a catalyst to both calls for higher standards and an ideology that instills “a respect, on the part of pupils and parents, for academic authority”, which he calls “the Discipline School” (pp. 132 & 155). But he also recognizes that this competitive system has costs that cut across racial and class lines, stating, “Compared with most other countries, the United States has more of its people subsisting on marginal incomes, often with little prospect of escaping their condition” (p. 155). He adds, “While race is a major reason why these gulfs and gaps persist, a lot of white Americans are also finding themselves falling behind” (p. 155).

He directs his critique toward those whom he calls “the mandarins” of the academy, most of whom are established professors of mathematics in elite universities, who impress upon incoming college students the kinds of skills they will need in order to

be proficient in mathematics courses at the collegiate level, likely, he argues, to fill "seats in their own PHD Programs" as opposed to contributing to the growth of individuals or the wellbeing of society. He thinks that at the heart of the mandarins' desire to "exert influence" over curricula is both their belief that only members of their coterie can teach "real" mathematics and their desire to safeguard their own prestige (pp. 113 & 179). He states, "That they insist on having sway over every level of instruction shows how ideology and ego can undercut efforts to address serious national needs" (p. 97 & 113). He notes that though the Common Core presents an emphasis on employment, geared toward "college or career readiness", he "could find nothing at all geared to occupational preparation" even "after examining its 1,386 standards" (pp. 122 & 123). And at the undergraduate level, he cautions that allowing mathematics' mandarins to have control over the "quantitative training" students need in order to operate high-tech equipment instead of "instructors familiar with each field's needs" "is a surefire recipe for failure" (113).

He 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. He writes that it,

> doesn't have a preset answer pupils are expected to find. Just to start, there's its ambiguous word 'could.' We're not told whether to look for the largest possible total, or all feasible variations. That, presumably, is left to the students, perhaps in a collaborative discussion. And there's room for more thought and creativity …. (p. 132)

The Discipline school, however, has its roots in the thinking of William McGuffey, "the nineteenth-century textbook author, who felt that young people should learn that academic regimens will be firmly enforced" (p. 135). Hacker associates the Discipline School, or the "Discipline rubric", with mandarins, explaining, "I've used the Discipline rubric for their position because they stress the tenacity needed to penetrate their subject. Moreover, they seek to preserve and promote mathematics as an intellectual pursuit and sphere of study," even, as he claims, for elementary school children (p. 133). He suggests that mandarins are interested in what occurs at this level because they desire to prepare next generations of specialists in their field (p. 134). Discipline approach advocates thus value students' absorption of "formal mathematics" (p. 143).

Based upon a series of comments made by advocates of the Discipline school, he makes the point that it is based upon an ideology that eschews allusions to "the beauty of mathematics, its intellectual provenance, or its place in the natural universe" (p. 138). All of the advocates' "allusions to character and discipline, persistence and rigor, precisions and patience," he states, "are presented as traits they imbue in themselves" as "moral

models" who have, with pride, survived the rigors of the system they now seek to perpetuate, with "'no pain, no gain'" as a guiding motto (pp. 137 & 138). Moreover, classroom practices and layout, including regimented textbook readings and neat rows of desks, indicate an adherence to traditional pedagogy. He remarks that the school's predilection for one-solution answers is also commensurate with "good preparation for the ACT, the SAT, and the Common Core 'assessments,' which many states will use to decide who will receive high school diplomas" (p. 138). Ultimately, in the Discipline school, "There is only one correct response, and it's what you need to get" (p. 132). It thus promotes the pursuit of the correct answer, a mathematics curriculum 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). In this view, mathematics is rendered essentially as "a metaphor for national supremacy, economic preeminence, and a resolute citizenry" (p. 138).

Hacker ultimately advocates for the Deweyian Discovery school, with its emphasis on students collaborating upon multiple solutions to real problems (pp. 132, 139, & 140). He also supports "public numeracy", at the heart of which is the learning and application of arithmetic to real problems (p. 171). And at the undergraduate level, he wants to see instructors who are field specialists, and not mandarins, teach students the respective technological skills they need in order to be prepared for their careers (p. 113). Furthermore, consistent with Dewey's disavowal of disciplinary hierarchy, he 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 civilization depends more upon science, technology, engineering, and mathematics than upon the range of human talents and endeavors (p. 11).

Hacker's case for STEM education thus promises the same advantages that come with progressive forms of education. It offers an uncompromising focus on the interests of the learner for the ultimate attainment of personal and intellectual growth. This could be the most attractive feature of Hacker's case. Moreover, his case takes issue with those aspects of public education that may serve to delimit students' autonomy, including standardized tests, a common national curriculum, and the deployment of mathematics as a mechanism for sorting learners according to their computational acumen. His progressive reconceptualization of the teaching of mathematical literacy as a practical, useful form of knowledge for everyday tasks is also an attractive feature of his case. Framing mathematics in this way strips it of its divisive academic elitism and capacity for social stratification.

At the same time, could Hacker's progressive vision undercut facets of the Discipline School that could actually be attractive under certain conditions? For example, is it possible that student competition has efficacious outcomes, cultivating within a community the desire and skills to become competent within an academic discipline? Is he fair to mathematics professors when he charges that they are self-interested "mandarins" of the academy? Is it possible that demanding educators, with their high expectations, play an important role in developing within learners particular habits of thought and capacities for taste and intellectual discernment? What, in other words, is the

extent to which a Discovery School-oriented STEM paradigm would undergo a watering down of the curriculum, to the point of the transmission of basic literacy skills? Moreover, is a progressive orientation to STEM education, one that might even deconstruct and rearrange the STEM acronym in the pursuit of students' interests, the best orientation to adopt for the satisfaction of egalitarian socio-economic and educational aims? Or are there other philosophical or ideological approaches to education that could effect a STEM educational paradigm better suited for democratic social conditions?

Comparing the Cases

Ultimately, there are important tensions between Bybee's and Hacker's cases. Whereas Bybee is in favor of the Common Core State Standards, claiming, "The implications for the Common Core State Standards for Mathematics and English Language Arts and Literacy and the Next Generation Science Standards also seem understandable and acceptable," Hacker thinks that standardized tests, including the ACT and SAT, as well as the Common Core State Standards, "with their unyielding stress on trigonometry, precalculus, and advanced algebra, have created arbitrary and intractable barriers for students whose aptitudes lie outside of mathematics" (Bybee, 2013, p. 45; Hacker, 2016, p. 11). Hacker suggests that advanced algebra has been a "stumbling block" for children across class boundaries, though more surmountable for children in higher SES situations who have access to private tutors, when "there is no evidence that academic mathematics, at least not the kind students are being urged to learn, will be the lingua franca of the future" (Hacker, 2016, p. 10).

Hacker goes on to explain that the development of the Common Core can actually be traced to "a little-known business group called Achieve, Inc." which has had the backing of "high-tech and financial firms, like IBM, Intel, and Prudential Securities" and focused initially on mathematics (p. 118). He writes that Achieve, Inc. sought multistate implementation of its standards but lacked the reach to do so with only corporate donors. He explains that after its "directors struck an alliance with a not-for-profit group called the National Governors Association … the chief executives of all fifty states were cast as backing a vision of education based on mathematical training and technical employment" (pp. 118 & 119). Hacker's observation is consistent with Wayne Urban's (2010), that states' governors from both parties backed the excellence agenda under the Bush and Clinton administrations (Urban, 2010). Hacker adds that with the support of several universities, Achieve, Inc.'s plan worked, positioning its standards as a national educational plan.

Incidentally, Bybee has claimed that he supports the aims of the NGA as well as the objectives of the Common Core, writing on the former that, "The National Governors Association (NGA) published an update on state actions that address an agenda for STEM (NGA 2011). The NGA has two goals: Increase the proficiency of all students in STEM, and increase the number of students who pursue advanced degrees and careers," adding, "The stated reasons for the governors' goals are understandable and straightforward: STEM occupations are among the highest-paying, fastest-growing, and most essential jobs for economic growth and innovation" (Bybee, 2013, p. 44). And on the latter, he writes, "The implications for the Common Core State Standards for

Mathematics and English Language Arts and Literacy and the Next Generation Science Standards also seem understandable and acceptable" (p. 45).

On the other hand, Hacker laments that, "The Common Core's one-size-fits-all will derail these young people at an early age, by inflicting a mathematics matrix that is not needed for all kinds of fulfilling lives" (p. 129). In fact, he reasons that what has resulted is a rigid mathematics regimen that "leads to a de facto form of tracking," whereupon "Upwards of one in five of our ninth-graders now leaves high school without a diploma, and the most common academic reason is failing to fulfill mathematics requirements" (Hacker, 2016, p. 125). Moreover, he challenges two myths about employment in the STEM fields: that jobs in STEM are lucrative and that there is a shortage of qualified workers for them. To the contrary, he states that within engineering, for example, companies are able to hire new graduates rather cheaply, "offering salaries acceptable to men and women in their twenties" (p. 33). And with respect to the putative shortage of qualified workers for jobs in STEM, he explains that workers who are qualified for specific jobs may end up not even applying to them due to unattractive wages or other preferences not accounted for in the rhetoric surrounding the "shortage myth" (p. 34).

Ultimately, he argues that in the future, "New talents of many sorts will surely be needed. But first to require that all show proficiency in parabolic geometry will actually hinder the emergence of strengths not based on equations" (p. 10). He thus cautions us that framing progress in terms of academic achievement in STEM could restrict society's conception of excellence itself: "As a society," he warns, "we had best be careful that we

are not constricting—not to say contorting—our conception of excellence" (p. 24). Compared to Hacker's skeptical position toward the NGA and the Common Core and his critique of the rigid mathematics schedule that has emerged in our schools, then, Bybee's position seems inadequately attentive to and critical of these concerns.

Pursuing Excellence

Another curious aspect of Bybee's case is his markedly dismissive stance toward the social reform movements of the 1960s and 1970s for their putative curtailment of the academic pursuit of excellence. This position is apparent when he states,

> Just as social and political factors had initiated and supported the Sputnik era of educational reform, social and political factors also arose in the 1960s and 1970s and acted as countervailing forces to the pursuits of excellence, high academic standards, and an understanding of the conceptual and methodological basis of the science, technology, engineering, and mathematics disciplines. (Bybee, 2013, p. 18)

By "social and political factors", he means that,

> In the 1960s, society increased its attention to civil rights, poverty, and an escalating war in Vietnam. Socially, we entered an era of criticism and protest that education did not escape … The criticisms of this period were many, deep, wide, and continuous. At the same time, constructive solutions were few, shallow, narrow, and short-lived. (p. 18)

He is ultimately critical of the calls for educational reform during the 1960s and 1970s, claiming that we have never escaped them and that they have essentially impeded

"pursuits of excellence, high academic standards, and an understanding of the conceptual and methodological basis of science, technology, engineering, and mathematics disciplines" (p. 18).

Like Bybee, Jennifer Jolly (2009) appears to refer to the focus on underserved populations during the 1960s as one of the reasons for the divestment from gifted education during the National Defense Education Act (NDEA) era. She writes, "funding and interest in gifted education diminished as the 1960s Civil Rights movement moved the focus to underserved populations, including those receiving special education services and minorities" (p. 52). She thus contends that,

> Gifted education's relevance fluctuates according to America's perception of critical need for the abilities and talent of the nation's most capable students. The era of NDEA clearly exemplifies gifted education's significance gained due to a national crisis, resulting from the Soviet Union's technological advancements. However, this relevance can easily dissipate when efforts, interests, and funding are directed elsewhere and other critical need areas are not identified. (p. 53)

Similar to Bybee, she expresses an understanding of students and STEM education as essential elements for a strong economy and country. For example, she writes, "Rather than competing with one rival, such as the Soviet Union, the U.S. is operating in a global marketplace" under conditions of a "'quiet [STEM] crisis'" in which there is "an increasing lack of interest by U.S. students in STEM careers" (p. 52). She concludes, "Gifted students represent an immense untapped resource—one that should be relevant regardless of the impulse of a critical need" (p. 53).

Origins of the Excellence Agenda

According to Wayne Urban's (2010) history of the National Defense Education Act (NDEA) of 1958, "excellence" represents an ideologically charged phenomenon. In *More than Science and Sputnik*, he attempts to understand how the differing ideologies of various parties involved in the development of the NDEA influenced the development of the groundbreaking midcentury education legislation. It appears that Urban's analysis of the NDEA is consistent with Herbert Kliebard's (1995) argument that interest groups and their ideologies play a key role in the development of educational reform. As T. Gregory Barrett (2012) points out, Urban suggests that his work is different from other scholarship on the NDEA because instead of focusing on the pure legislative history of the act, it examines how political philosophies and ideology came to bear on how the legislation evolved and manifested into law (Barrett, 2012).

Contrary to an understanding of NDEA as a piece of educational legislation wholly subsumed by an emphasis on public education as a boon for national defense, Urban argues that it was more complicated than this and represented an amalgam of agendas. He writes that NDEA, as an "omnibus measure", "was both a science education and a much-more-than-science education measure, and it broke the dam against federal aid to education through astute use of a national defense metaphor by all of its proponents" (Urban, 2010, pp. 210 & 212). Owing to its intention to distribute federal aid to students in need at midcentury, he claims that it was "a liberal-moderate measure", "a breakthrough in the federal aid to education arena", and "had liberal democratic provisions pointing toward equity in some of its titles" (pp. 207 & 210).

At the same time, it had "excellence oriented policies and practices in other titles" (p. 210). He elaborates that "The liberal aspects of NDEA pointed toward its immediate successor measures such as ESEA and two higher education acts, but its excellence titles pointed toward the repudiation of equity in the interests of educational excellence that would be the goal of federal policy after 1980" (p. 210). He concludes,

> If this description is correct, NDEA then was both liberal and conservative, equity and excellence oriented, and it resulted in both a breakthrough in the amount of federal funding for education that resulted in a strong equity emphasis in federal educational policy and a prefiguring of the direction that federal educational policy would take as it broke away from the equity orientation and the emphasis on federal funds without abandoning either completely. (p. 210)

For Urban, the shift in the direction of federal educational policy away from an equity orientation and toward an excellence orientation is the result of several factors. He explains that the Carter administration's omission of the enhancement to federal aid as an agenda item slowed the momentum of NDEA's decades-long provision of federal aid to educational interest groups (p. 207).

It was the Regan administration, however, that upended the use of the NDEA a means for providing federal aid by devolving the federal government's role in "educational activism" (p. 208). He writes, "Ronald Regan in his attack on federal educational activism moved the focus for educational affairs firmly back to the states and local school districts" (p. 208). Ironically, the cooperation that occurred between the federal government and states resulted in an expansion of the federal government's power

into educational issues, though "not in the interests of equity or equality" (p. 208). It entailed the "testing of students in core subjects and the setting of high standards of achievement for those tests", practices "endorsed enthusiastically by the nation's governors from both parties" (p. 208).

Part and parcel of this movement away from federal educational activism was a preference for school choice and a dissatisfaction with public education. Moreover, *A Nation at Risk*, "produced by a presidentially appointed committee on education", catalyzed "The gradual replacement of the free spending equity agenda of NDEA-ESEA with an excellence agenda" (p. 208). Urban explains,

> Using a language of fear of economic competitors such as Japan that was just as apocalyptic as much of the post-Sputnik, anti-Soviet rhetoric that framed the political climate within which the NDEA was developed, 'A National at Risk' helped to inaugurate an educational excellence agenda at the federal level that came to be seen as anti-public school by many within the elementary, secondary, and college and university teacher education universe. (p. 208)

Moreover, constitutive of this shift into an excellence agenda was the requisition of "more and more curriculum change, systematic pedagogy to teach the changed curriculum, and a rigorous measurement system to assess the results" (p. 208).

Critiques of the Excellence Agenda

Consequently, one way to interpret Bybee's (and even Jolly's) advocacy of the pursuit of educational excellence in lieu of the social reform movements of the 1960s and 1970s is by associating them ideologically with the conservativism that gave birth to the

excellence agenda in the 1980s. Hacker's dichotomy of the "Discovery" and "Discipline" schools could also be instructive here, the latter being more thoroughly descriptive for Bybee's ultimate understanding of STEM literacy as a means for safeguarding the nation's economic and political security.

Carl Kaestle (1991) might take issue with this sense of dismissiveness toward the social reform movements of this era, having argued that "we disagree with the perspective that blames a collapse of standards on the turbulent sixties and looks to test scores to measure whether educational problems have been resolved" (Kaestle, 1991, p. 145). Ira Katznelson and Margaret Weir (1985) might also disagree with this position, having written that "the relative quiescence of the past decade is no indication that black educational issues have been resolved. Rather, the absence of the unruly questioning of the 1960s signifies an impasse in the search for means to achieve equal education for blacks" (Katznelson & Weir, 1985, p. 206). Michael Katz (1987) might also be critical of this sentiment, having argued that the "effective school movement" of the 1960s and 1970s, putatively the "social and political factors" to which Bybee and Jolly refer, "no longer represents the cutting edge of reform" (Katz, 1987, p. 129). "Within only a few years," he writes, "it lost its place to a hard new emphasis on 'excellence.'" (pp. 129 & 130). He continues, "In retrospect, the effective schools movement was one of the last and most interesting products of concern with poverty and civil rights that surfaced in the 1960s'; 'excellence' is a product of the revived Cold War and its new domestic agenda" (p. 130). Contrary to Bybee's assertion that the "social and political factors" of the 1960s and 1970s "created an era of criticism and protest that education did not escape," for

these authors, these factors did not go far enough toward addressing inequality in public schools at that time (Bybee, 2013, p. 18).

Katz also criticizes the rhetoric of "excellence" within "the 1983 report of the National Commission on Educational Excellence, *A Nation at Risk: The Imperative of Educational Reform*" and its implications for the development of hierarchies within educational contexts (p. 130). He explains that,

> By definition, excellence implies stratification. To excel is to achieve at a level beyond the ordinary. Within schools, excellence implies the recreation of hierarchies that give primacy to academic achievement and link achievement more closely to rewards in the world of work. It calls, in short, for a rigid meritocracy. (p. 131)

He suggests that one problem at the heart of such a rigid meritocracy is its tendency to reify preexisting inequality. He states, "For many reasons, meritocracies usually serve best those who enter them with a favored position, and it is not hard to predict who will appear most excellent and garner most rewards. A policy stressing excellence, therefore, is another way of redistributing rewards upward" (p. 131). He suggests that this shift of resources toward those who are already thriving in and as a result of the system is nothing new, stating, "As has usually happened in the past, a new educational policy proposed in the interests of everyone would serve best those already privileged" (p. 131).

A Critique of Bybee

Because of Bybee's putative conservatism and congruity with Hacker's Discipline school, it seems that he effectively turns away from the Deweyian perspective he had

proffered early on in his work. As Dewey demonstrated, the hierarchizing of disciplines, and in this case those of STEM, for the purposes of nationalistic and economic aims would be detrimental to the enactment of education as an integral experiential component for the development of rationality. Proposals like Bybee's that posit STEM literacy as a key facet for maintaining American geopolitical supremacy thus portend an illiberal educational experience for students because they limit the extent to which what is taught and learned in schools arises from authentic student interests.

If we seek a conceptualization of STEM education that places students' autonomy and growth above other extrinsic considerations, we should place more stock in progressive visions like Hacker's and even Katz's. Like Hacker, Katz suggests a "competence" model of education in lieu of a system focused upon meritocracy for excellence. Aware that schools "do fail their students, and they fail most badly those with the least ability to look for help elsewhere and with the fewest resources to help compensate for an adequate education", he argues for the focus to be upon the development of students' "crucial cognitive abilities" instead of excellence (Katz, 1987, p. 131). And like Hacker, he alludes to the underlying democratic sentiment within the conception of competence, "the educability of everyone" (p. 131).

Moreover, in accordance with both the Vega model and Chesky and Wolfmeyer's critical investigation of STEM education, we can understand Bybee's work as an ideological artifact embedded within a system of dominant cultural reproduction. In the end, and in alignment with arguments for STEM education from conservative figures like Scott Walker, it places a heavy emphasis upon the inculcation of STEM literacy for the

cultivation of nationalism, militarism, and capitalism. Bybee's dismissiveness toward the social justice movements of the 1960s and 1970s for their putative impingement upon pursuits of academic excellent is thus a symptom of his weddedness and partiality to nationalistic over civic aims. Because of this, and despite its allusions to progressive aims, his case amounts to an endorsement of and potential instrument for the corporate-state. It never once questions whether or not it is a good thing to support the capitalistic status quo and, as a result, serves to support it. It thus also serves to promulgate STEM education for homo oeconomicus, the student as human capital and walking firm.

Lessons and Limits of Hacker

At the same time, and in light of Chesky and Wolfmeyer's critique of STEM education, Hacker's case does not seem to go far enough toward addressing the implementation of STEM education as an edifice of the corporate-state. Instead, it seems to sidestep the issue, offering the possibility that we agglomerate various disciplines together for whatever educational ends we might have in mind at the time. Despite the advantages its embrace of Deweyan progressivism brings to the table, it does not offer a nuanced alternative conceptualization of STEM education to which we might practically turn for the pursuit of social justice aims. Indeed, one of the alluring features of Bybee's case is that it provides a comprehensive and practicable vision for what STEM education could become. Ultimately, there seems to be the need for a conceptualization of STEM education that offers the same level of depth as Bybee's case, with the progressive impulse of Hacker's case, but with a further-reaching critical sensibility capable of addressing the issues that Chesky and Wolfmeyer bring to the fore.

The Critical Value of Student Experience

But Chesky and Wolfmeyer (2015), despite having informatively framed and examined STEM education as a major national educational policy discourse, have not interrogated STEM education as a curriculum that students experience. They explain why they have refrained from considering qualitative data by stating that,

> Philosophical method is the application of philosophical concepts to a particular domain of study. It includes the formulation of questions and problems and justifiable solutions to these. It does not occur by collecting and analyzing data on the lived experience, as is the case with a variety of forms of empirical research. (p. 8)

Underscoring the philosophical nature of their investigation, they encapsulate the purpose of their work by stating that,

> The primary purpose of this book is to shift the attention away from strictly utilitarian aims, geared to quickly and efficiently meet the STEM initiatives, and to take a step back and ask critical questions about what types of aims the STEM initiatives are asking for, what assumptions do such aims hold, and what possible implications or consequences could such initiatives have on various socio-economic groups, funneled through a public education system that is increasingly being tied to economic, capitalist incentives and procedures. In order to begin to answer the above questions, we will use a philosophical lens to study STEM policies as a political and social phenomenon. (p. 2)

But in light of the expanded Vega model's indication that students and their experiences of STEM education are a crucial element in the process of cultural reproduction and an inextricable facet of the nature of STEM education itself, Chesky and Wolfmeyer's domain of study for a comprehensive philosophical analysis of STEM education seems to be restricted in its preclusion of experience.

An analysis of students' actual experiences of STEM education could provide insight into the overarching process of dominant cultural reproduction in schools as well as offer another lens through which to examine the nature of STEM education today. More specifically, such an analysis could provide responses to questions like the following: Is STEM education an "oppressive" educational paradigm, as the foregoing theoretical critique would suggest, or is it capable of providing students opportunities for enjoyment and growth? If it is both, how should we understand its value and whether or not it should be changed? Is it ideologically hegemonic, or does it permit variation in the ways in which it is enacted and even perceived on the ground? Do students readily incorporate the messages they learn within a STEM educational program, or do they develop their own interpretations of what STEM education means to them?

In the following chapter, I will attempt to answer these questions by reporting on students' experiences of STEM education in one college-preparatory STEM school. At the core of this analysis is the attempt to understand the extent to which the foregoing theoretical critique of STEM education squares with descriptions of STEM educational learning on the ground. Ultimately, any insights gained from this analysis would then serve to inform and strengthen the theoretical critique. Before turning to possible

alternative conceptualizations of STEM education, then, it is important to address next the nature of STEM education as an enacted and lived phenomenon.

References

Barrett, T. G. (2012). Between citizens and the state: The politics of American higher education in the 20th century/*More than science and Sputnik: The National Defense Education Act of 1958*. *American Educational History Journal*, *39*(1/2), 251-263.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. Arlington, VA: National Science Teachers Association.

Chesky, N. Z., & Wolfmeyer, M. (2015). *Philosophy of STEM education: A critical investigation*. New York, NY: Palgrave Macmillan.

Johnson, S. (February 5, 2015). 'Wisconsin Idea' was rewritten per Walker's drafting orders. *Wisconsin Public Radio*. Retrieved from http://www.wpr.org/wisconsin-idea-was-rewritten-walkers-drafting-orders

Jolly, J. L. (2009). The National Defense Act, current STEM initiative, and the gifted. *Gifted Child Today*, *32*(2), 50-53.

Kaestle, C. F. (1991). *Literacy in the United States: Readers and reading since 1880*. New Haven, CT: Yale University Press.

Katz, M. B. (1987). *Reconstructing American education*. Cambridge, Mass: Harvard University Press.

Katznelson, I., & Weir, M. (1985). *Schooling for all: Class, race, and the decline of the democratic ideal*. New York: Basic Books.

Kliebard, H. M. (1995). *The struggle for the American curriculum, 1893-1958*. New York, NY: Routledge & Kegan Paul.

Martin, R. J. (1992). A model for studying the effects of social policy on education: Gauging the impact of race, sex, and class diversity. *Equity & Excellence*, *25*(2-4), 53-56.

State of Wisconsin Department of Workforce Development. (2014). Governor Walker proclaims STEM education week in Wisconsin. Wisconsin.gov. Retrieved from https://dwd.wisconsin.gov/dwd/newsreleases/2014/140311_stem_education_week.pdf

Urban, W. J. (2010). *More than science and Sputnik: The National Defense Education Act of 1958*. Tuscaloosa: The University of Alabama Press. Retrieved September 2, 2017, from Project MUSE database.

Wong, A. (February 11, 2015). The governor who (maybe) tried to kill liberal-arts education. *The Atlantic*. Retrieved from http://www.theatlantic.com/education/archive/2015/02/the-governor-who-maybe-tried-to-kill-liberal-arts-education/385366/

Chapter 5. Student Experience of STEM Education

Where Theory Meets Practice?

Three years prior to his work with Nataly Chesky, Mark Wolfmeyer (2012) commented on mathematics education as an instrument of the military industrial complex and implicated companies Boeing and Battelle in his critique. He states that,

> the drafting process for the new de facto US national math standards, the *Common Core State Standards*, included financial support from two large-scale engineering firms who happen to provide weapons to a number of nations: Boeing and Battelle. These firms provided monetary support to Achieve, Inc., the not-for-profit which was organized by the National Governors Association and Chiefs of School State Officers for drafting national standards (Achieve, Inc. 2010). Their funding suggests that mathematic knowledge is needed to engineer military products that will be purchased by nations for warfare. (Wolfmeyer, 2012, p. 42)

His analysis speaks to the putative importance of STEM education to the aims of American imperialism and is consistent with critics' assertions that socio-political, economic, and educational forces are working in concert to decimate public institutions, democracy, and even the demos itself. Andrew Hacker (2016), too, intimates that STEM education has dubious connections to the interests of national and corporate elites, claiming, "Not the least of my concerns about STEM is that it casts mathematics largely

as an arm of technology, in a global competition gauged to gross domestic product, military might, and electronic surveillance" (Hacker, 2016, p. 7). And like Hacker, Wolfmeyer points to the role of Achieve, Inc. in furthering mathematics education as a boon to neoliberalism and the corporate-state.

But what might it actually be like for students who study STEM education? Would we find evidence of the dominant cultural reproduction of neoliberal political rationality in their experiences of STEM education? Would we be able to say that the corporate-state affects students on the ground as the previous analyses suggest, or would we find evidence that students are relatively resistant to its alleged influence?

Exploring Student Experience in "STEM School"

During the past four years, I have worked with a research team that has been longitudinally surveying and interviewing students at one STEM-focused combined middle and high school in the Midwest. "STEM School" is a college-preparatory, mastery-oriented, quasi-public, lottery-based school that is funded in part by the Battelle organization. Although our research is ongoing, between May 2014 and May 2018, my team and I have interviewed 23 of STEM School's students a total of 90 times over the course of six semester-coinciding waves, though not during the autumn semesters of 2016 or 2017 due to a majority of researchers' shifted interest in analyzing survey data. Additionally, the study's original IRB approvals did not permit classroom observations or pedagogical content analysis. As a result, interview participants' accounts are the sole resource in this study for providing an illustration of what STEM education means and looks like in this school.

In this vein, a former administrator of and active teacher at STEM School provided our team with a detailed account of the school's origins and inner workings. They explain that STEM School was originally started in 2006 as a lottery-based, STEM-focused educational program for the various schools within its county. Since then, it had become a state-wide educational hub. They state that, "the idea was a small school with a big footprint", and that early on, no student ever officially graduated from STEM School. After four years in the educational program, they would graduate from their home schools. They point out that after the financial recession of 2008 and a reshuffling of school district support, STEM School would eventually be granted its own district and access to state funds, alongside continued funding from Battelle and its associated university. They state that a fundamental mission of STEM School was thus "to prepare kids… for college, prepare them for careers". Part and parcel of STEM School's mission as a "small school with a big footprint" has thus been its provision of "partnerships with our early college experiences". These partnerships entail connecting STEM School's students with other districts and university services for field experiences in such areas as "energy, environment, economics … social and physical science" and "biomedical engineering … robotics, engineering".

They continue to explain that STEM School's mission as "a small school environment focused on early college" has been to focus "on a pervasive set of… skills" that constitute "effective communicator and collaborator, active responsible decision maker, critical thinking, engaged learner, and inquiring learner". It has also been STEM School's mission to follow Battelle and its associated university in promoting STEM

principles, as “That’s what Battelle and [its associated university] said, whether it’s college or it’s [the] professional world, these are the skills that determine success” and “That are the best predictors”. Furthermore, the use of a problem-solving pedagogy and the integration of “21st century skills” were key methods by which STEM School promoted STEM principles at the level of learning. They state, “We look at STEM as a state of mind – very problem based”. They also explain that they have attempted to integrate technology in the specific classes they teach, or “social science … history, government, economics”. And within classes, they strive for authentic activities and projects, such as the drafting of a white paper to be sent to a political actor for affecting public policy.

Moreover, a facet of STEM School’s curriculum centers on interdisciplinary “design challenges” that entail students drawing upon multiple disciplines to solve a design-based problem. One of the interviewed students describes a design challenge in detail, stating,

> “you might have something you have to design… like recently I did a chemistry project where I have to make a box that would insulate a drink and… so… You know, sometimes it’s a little bit more about design and then depending on like [an] English class I have more of projects where you have to write out or type a paper or type an essay or something like that.”

Specific classes offered at STEM School during the period of study include Prealgebra, Algebra I and II, Trigonometry, and Probability and Statistics, for middle school mathematics; Automation and Robotics, Bugging Out (Entomology), Design and

Modeling, Language of Science, Magic of Electrons, Natural Disasters, Physics of Transportation, and Who's Swimming in the Gene Pool for middle school science; Algebra I and II, Trigonometry, Geometry, Pre-Calculus, and Calculus for high school mathematics; and Biology, Chemistry, Energy and Matter, Environmental Science, and Physics for high school science. STEM School also offered classes in Social Studies, English, and Art for both middle school and high school students. The reason our team has records of the specific class names in middle and high school mathematics and science courses is due to the fact that we based our quantitative, survey-based research on these particular classes.

Method

Over the course of the study, we have asked students at STEM School about a range of topics, including about their expectations for matriculating at the school, experiences with classwork and homework, positions on the school's mastery-based assessment system, perceptions of what it means to be a student at the school, and thoughts about the school's social environment and the extent to which they feel like they belong there. We have also asked students about how they feel and what they think about STEM education itself.

The interviews have been comprehensive. My team wanted the interview protocols to be broad enough to elicit data that could offer a holistic portrait of students' lived experiences at and of the school. Because members of the team have also expressed diverse research interests, we sought to acquire data in a way that could support various research directions. For example, an analysis using the data could be put to any one of a

number of purposes, including as a report to the school's administration for addressing potential curricular concerns or as an exploratory study for a professional conference, delving further into any one of the various domains of student experience we have explored, such as motivation, belonging, and procrastination.

Indeed, I have seen and assisted my colleagues, who are educational psychologists, prepare the study's qualitative and quantitative data for just these aims. At the same time, I have intended to use the study's data, and more specifically, its qualitative data, differently, as an important facet of a broader philosophical analysis of the nature of STEM education. To this end, I plan to review students' comments about the extent to which they enjoy studying STEM in light of the broader philosophical analysis I have been developing thus far.

Although my analysis of students' comments should not be considered a comprehensive qualitative study, it will resemble one in several ways. For instance, I plan to curate, present, comment upon, and address general trends in the data, including, for instance, the percentage of students who report that they enjoy studying STEM. But importantly, I will refrain from undertaking an exhaustive analysis of the data which would be expected within a comprehensive qualitative study. This is outside of the scope of this philosophical project. Rather, I will present students' comments narratively to develop a characterization of STEM education that is emergent from students' lived experiences.

It should also be noted that not every interview entailed asking students specifically about studying STEM. Our team regularly amended the interview question

protocol to address different topics in different waves. We also reserved specific questions for new, as opposed to continuing, participants. We planned to ask students specifically about the extent to which they enjoyed studying STEM both during the first three waves of interviewing to those participants who were new to the project, and then also during the fifth and sixth waves of interviewing to continuing participants. This means that out of a total of 90 interviews, 45 of them were designed for asking students about the extent to which they enjoyed studying STEM. Essentially, every interview discussed in this study focused on students' responses to the same basic question: "Do you enjoy studying STEM?"

But five important caveats to this plan should be noted. First, during a first-wave interview, an interviewer did not ask an interviewee about the extent to which they enjoyed studying STEM. I have removed this interview for consideration. Second, during a second-wave interview, an interviewer asked an interviewee (Participant 13) "how they felt" about studying STEM instead of "if they enjoyed" studying STEM. I have noted this nuance in the data table in Appendix B. Third, three interviewees (Participants 8, 9, and 16) offered their perceptions of studying STEM prior to the interviewers directly asking them about it. I have noted this nuance in the data table. Fourth, despite STEM School being a combined middle and high school, all interviewees at the time we conducted the selected interviews were middle school students. No data on high school students' perceptions of STEM are, therefore, reported in this project. And fifth, the thirteen, fifth-wave interviews and nine, sixth-wave interviews have not yet been transcribed and are inaccessible to this analysis. I have reserved them for future research. Moreover, these

interviews have entailed asking continuing participants a second and third time, respectively, about the extent to which they enjoyed studying STEM. Although this data is valuable for longitudinal analysis, I will review participants' first-time responses to this question in this project. These caveats mean, therefore, that there are 22 interviews accessible to this analysis.

Findings

I have organized the pertinent contents of these interviews, or interviewees' responses and their reason(s) for their responses in their spoken and unedited form, in a data table in Appendix B. According to these 22 interviews, therefore, 16 participants indicated that they enjoyed studying STEM (73%), 5 participants indicated ambivalence toward studying STEM (23%), and 1 participant indicated that they did not enjoy (or disliked) studying STEM (5%). Participants expressed enjoyment, ambivalence, and lack of enjoyment (or dislike) in various ways.

The 16 participants who indicated that they enjoyed studying STEM offered various reasons for their enjoyment, including: prior enjoyment of the STEM subjects (e.g., that they were passions or hobbies); the perceived appeal of the subjects themselves (e.g., that they were "cool", "fun", "useful", challenging, and interdisciplinary); the ways in which the STEM subjects were conveyed or explored (e.g., via "experiments" or non-textbook methods which reduced the burden of reading); the fact that the STEM curriculum deemphasized subjects they did not like (e.g. "literature"); the fact that they were adept at one or more of the STEM subjects (e.g., skill with solving mathematical formulae); the potential for the STEM subjects to permit participants to express facets of

their identity (e.g., being "geeky"); the capacity of the STEM subjects to give participants opportunities for invention, innovation, and revelation (e.g., creating "a different type of car" and "being able to see inside the computers"); the academic, occupational, and professional preparation the STEM subjects putatively offered (e.g., for college chemistry and the "medical field"); and the fact that the STEM subjects were actually on offer at STEM School and were not at previously attended schools.

Meanwhile, the five participants who indicated that they were ambivalent toward studying STEM offered various reasons for their ambivalence, including: the fact that the STEM subjects themselves are not preferred or favorites; that they were not adept at the STEM subjects (e.g., science); that they were unaware of what STEM education actually was; that the STEM subjects were already commonplace in schools other than in STEM School; the need to focus on priorities other than studying STEM (e.g., improving grades); the extent to which studying STEM was unconducive to stated career pursuits (e.g., becoming a counsellor); and that matriculation at STEM School was not a choice and was mandated against their will (e.g., they were "forced to come here").

Finally, the single participant who indicated that they disliked studying STEM offered various reasons for their dislike, including: the fact that the STEM subjects are uniquely challenging; the coursework was not interesting; they identified more with the humanities than with the STEM subjects (e.g., "English and arts"); and that they "had" to study math, a comment resonant with another participant's remark that they had been "forced to come" to STEM School.

The majority of participants thus reported generally favorable perceptions of studying STEM and offered various reasons for these perceptions. At the same time, a minority of participants reported ambivalent or unfavorable perceptions of studying STEM and offered various reasons for these perceptions. The findings suggest that participants' perceptions of studying STEM are, nevertheless, complex. Although there appear to be patterns in their perceptions of studying STEM (e.g., how STEM is instrumental for academic or career development), it would be inaccurate to claim, for instance, that they perceive studying STEM in the same ways or for the same reasons. This also suggests that the very meaning of and rationale for "enjoyment" is open to interpretation. It appears, therefore, that the 16 participants who indicated that they enjoyed studying STEM can be categorized into three subgroups.

The first subgroup (A) includes six participants who indicated that they enjoyed studying the STEM disciplines as "ends in themselves", with one commenting on her adeptness for them as being intrinsically valuable to her. Participant 4 says that he has "always been a fan of Math and Science". He even remarks approvingly that "You actually get a whole period of [Algebra I] and that's nice". Participant 14 says that she really likes math and science and that she is "not a big fan of language arts" and how this is "kind of good" that "they don't really focus on it". She adds that technology is fun and iterates how she likes that STEM School focuses "on the things I really like". Participant 15 states emphatically that the STEM disciplines are her favorite "out of anything" and that "If I could just not take a literature subject and take another science course, I would definitely do that". She makes the caveat that even though "they say that literature" is her

best subject, “it’s definitely not my favorite”. She adds that STEM School provides a forensics class and that it is “really fun”. Participant 10 states that the provision of STEM education is “one of the reasons that I chose to go to [STEM School]”. She then provides a sophisticated rationale for her interest in STEM education, hinging on how the disciplines feed into one another, catalyzing inquiry. She states that, “science sort of links to technology. It … makes you want to inquire more and study the things that you really enjoy”. She then likens this desire for inquiry in the STEM disciplines to that in the arts, explaining, “Like people that like art might want to look into arts and music”. She concludes by suggesting that interest in the STEM disciplines reveals one’s “geeky” side and that “most kids enjoy showing that they’re a little geeky and that they enjoy … technology and innovation”. Participant 7 provides insight into what Participant 10 discussed, a desire for inquiry into the STEM disciplines, and elaborates upon how this desire could translate into innovation. He states, “I’m mainly interested in the way that … machines work, and … how to make machines do a specific purpose”. He adds that science could play a role in the development of new creations, like “a different type of car” and “hovercraft and aircraft technology”. Finally, Participant 16 explains that she likes science and technology and that they interest her, the former because science permits her to be “able to learn about … different parts of the body” and because it is “medical” to her, and the latter because technology permits her to be “able to see inside the computers” and “how to program”. She also states that she helps her friends with mathematics and how her efficacy with it is edifying. She says, “I just like being able to solve the different equations and knowing that … I solved this equation and … really

hard equations that I didn't know I could be able to solve". She adds that her perspicacity for mathematics "just lets me know … I'm really good at this" and "actually good at something".

The second subgroup (B) includes five participants who indicated that they both enjoyed studying the STEM disciplines as "ends in themselves" and perceived them as future academic or career options. Like Participant 16, Participant 2 makes it a point to discuss how her enjoyment for studying STEM is tied to her efficacy with the disciplines. She states, "It's what I'm good at. I'm … good at math; I'm good at science". She adds that although she likes reading "and that kind of stuff too", she thinks she will eventually "end up" in STEM. "Even before I came here," she remarks, "I knew that's what I wanted to do". Participant 12 states that he likes all of the disciplines and "science and math the most". He adds that "They're all interests of mine" and remarks that he wants to pursue chemistry at the collegiate level. Participant 11 proclaims that science is her favorite subject and that she loves math. She concedes that English and social studies are "still important" and that STEM School does focus on them, but that they are "kind of lower than the science and the math" and that the latter represent "what's really important". She continues to explain that she intends to become a physicist and that STEM School's focus on math and science is "nice" and an "opportunity". Participant 3 asserts that STEM is something she has always been interested in and that in her former school, she had participated in a STEM club. She identifies mathematics in particular as being interesting and likely her favorite STEM discipline. She adds that she plans to pursue the medical field "related to Science and Math" and remarks how she feels that

learning about “these things” “will be a good thing for me”. Finally, Participant 9 expresses how technology is his “passion” and how he has “always liked coding and computers”. He adds that he is taking a forensics course and that it is “very, very interesting” and how he “would love to do that” when he is older. He concludes by stating that “coding is basically a hobby” and that it is “something I would actually like to get into”.

The third subgroup (C) includes five participants who indicated that they enjoyed, or perhaps more accurately, valued, studying the STEM disciplines insofar as they could provide them with general use or benefit for life and work. Participant 5 thinks that studying STEM is “actually really useful”, states that he really likes math, and explains that he did not have access to much math at his old school. He specifies that “the math part is really … useful” and adds that he likes “all they got here”. Participant 1 suggests that STEM School does not have textbooks, and due to this, they do not have to read. She explains that they do engage in many experiments. She muses that “you need to get ready for life”, that “in life everything is not fair”, and “so they kind of pushing me”. Participant 6 remarks that the STEM subjects are slightly more challenging, “but are still very important in your life skills”. He adds that, “it’s great to focus on those because it’s something you really need to have down and you need to understand and I think that’s been helpful”. Participant 13 finds studying STEM to be “very beneficial”. She describes what this means by explaining that “I will use it later on in life” and that “science is related to everything and so is math”. She then posits three general and interrelated ways in which the study of STEM is beneficial. First, learning about technology and

engineering in particular will allow you to be “advanced” and ready for a future that is itself evolving toward engineering and technology. Second, being “advanced in everything” will “help you get the job you want”. And third, this enrichment will generally “help you become what you wanna be”. Finally, Participant 8 states that she was “really excited to go to a STEM school because I really enjoy that stuff”. She elaborates that she is better at science than at math, and that STEM school permits her to “move on with science” and “stay behind in math”. She adds that attending STEM School was ultimately and clearly a “lucky opportunity” and explains that when she discovered that she had been accepted, “my dad’s like ‘I did not think you would get accepted, this is a rare opportunity, and you need to take it and run with it’”.

A final subgroup (D) could combine the five participants who reported that they were ambivalent toward studying STEM and the single participant who indicated that they disliked studying STEM. Participant 19 states that she does “enjoy studying … some of the things that we are doing” but remarks that she does not “really understand much about the STEM program”. She adds that right now, she is “just concentrating on trying to get my grades up”. Participant 21 thinks that studying STEM is “okay” and reasons that STEM school provides a “more standardized” and “good” curriculum so that “you can have what you need”. She appears to offer a critique of STEM School’s grading schema, however, remarking, “But … the grade work still definitely needs work”. Participant 20 thinks that studying STEM is “alright” and clarifies that it is not really his favorite subject. He seems to imply that STEM School is not all that unique, reasoning that “every school has science and … math” and that they, too, incorporate technology

into these subjects, as well as science and technology in labs. Participant 17 states that studying STEM education is "okay". She explains that although she wants to be a counsellor, she will "just stick to STEM" for now. Participant 22 states that she "kind of" enjoys studying STEM, but that she does not like math or engineering. She clarifies that she does like natural science, biology being an example. She goes on to explain that she is actually "more of an English and arts type of person than math and science" and "that the coursework won't always be super interesting", seemingly implicating science coursework in this assessment. She specifies that she had taken a science class called "physics and transportation" and did not like it because "physics is basically a second math class". She adds that she "[had] to do them, because it's math". Finally, Participant 18 states that she "kind of" enjoys math and really likes science, but that she is "just really bad [at science]. She adds that she "didn't choose [STEM School]" and that she "was forced to come here".

STEM Education as Symbolic Capital

One way to interpret students' experiences is by construing STEM education and literacy as an emergent form of symbolic capital within a class-based and vocationalized educational system primed for an increasingly technologized marketplace in a capitalist state. Aforementioned cases for STEM literacy frame its acquisition as a promising means by which students can attain some measure of middle-class stability. Resonating with Andrew Hacker's (2016) argument that ever-increasing educational standards exacerbate occupational inequality, Ralph Collins' model of educational status, as

reviewed by David Hogan (Anderson, Kantor, and Tyack (1982)), theorizes that people compete in order to gain status, which they believe education can afford them.

This competition catalyzes an increased demand for schooling which is dislocated from the actual skills the economy requires. Low- and middle-status groups will raise their educational standards, perhaps including longer years in educational programs, in order to gain status for their members. But higher-status groups will, at the same time, raise their standards in order to protect their dominance. "In response," Hogan writes, "low-status groups will again attempt to close the gap, and so on in a continuous spiral" (Anderson, Kantor, & Tyack, 1982, p. 164). He continues,

> The principal consequence of this spiral, according to Collins, has been to increase the supply of educated labor. This in turn has allowed employers continually to upgrade the educational requirements of jobs that to all intents and purposes have not changed in their objective skill requirements; thus the credential gap noted by Berg. Cognitive skills are produced in excess of the demand for them; an imbalance appears between the demands of the economy and the supply of educated labor. Because of this, the expansion of educational achievement does not necessarily decrease inequality of opportunity. High-status positions are still out of the reach of most low-status groups, despite levels of education that earlier would have entitled them to such positions (p. 164)

Hogan describes this as an "inflation of credentials" and writes that according to Collins, this, as well as "the growing belief by employers that job-specific training, rather than educational credentials, is the better way to acquire high-performance workers", has led

to a decrease in the public's "confidence in education as a means of social mobility" (pp. 164 & 165).

He points out several problems with Collins' model, however, among which is that it "does not explain the politics of educational expansion", including such things as compulsory education, vocational education, and testing, and, therefore, the possibility that, "elites imposed many of these features on the educational system in an effort to ensure that incorporation of students into the various ideological practices of capitalist society and to develop institutions that would effectively channel into a differentiated and stratified labor market" (p. 165).

Another of Hogan's criticisms of Collins' model is that it misconstrues, fails at accounting for, and does not explain the "significance in different class structures" of both working- and many middle-class parents' motives for sending their children to school: He states,

> Working-class and middle-class educational behavior was less a search for status than a rational response to a wage-labor society—education was widely believed to be first and foremost the key to economic survival. People send their children to school in order to enhance the market value, whatever its fluctuations, of their children's labor power. Educational behavior, then, cannot be understood independently of the structure of class relations, particularly in the wage-labor system. (p. 165)

He ultimately laments that "If the triumph of the market in politics, as in the economy, left nothing but the pursuit of self-interest; if in culture it left nothing but narcissism and

the psychedelic bazaar, if in human relations nothing but the cash nexus, in education it has increasingly left nothing but vocationalism," and that, "It is this forging of new institutional alignments between the economy and schooling that a class analysis of American education can make intelligible" (p. 179).

STEM Education for Homo Oeconomicus

Another way to interpret students' experiences of STEM education entails seeing them not just through the lens of class analysis as being constitutive of symbolic capital acquisition within a capitalist society, but perhaps more fundamentally through the lens of critical theory as being expressive of the subjectivity of homo oeconomicus within neoliberal governmentality. Hogan's allusions to "the triumph of the market in politics, as in the economy", the "cash nexus" which pertains between and characterizes human relations, and the "forging of new institutional alignments between the economy and schooling" that "has increasingly left nothing but vocationalism" are nicely consistent with the critiques of the corporate-state at the core of this analysis, and perhaps most so with Wendy Brown's (2015) panoptic analysis of neoliberalism and its systematic impact upon the demos.

Like Hogan, Brown comments on the role that families play in their children's academic and occupational choices, but distinctively how they do so under the sway of neoliberalism as a form of political governmentality. She states that, "Students are pressured by families and cultural norms into choosing business, engineering, and preprofessional majors over those in the arts, humanities, and interpretive social sciences" (Brown, 2015, p. 183). According to the expanded Vega model, families'

"pressure" and corollary rules would themselves emanate from and be constitutive of the dominant cultural norms propagated by the corporate-state apparatus. Moreover, students' attitudes, opinions, and beliefs would correspond to and be influenced by these norms.

Participant 8's account seems consistent with this analysis. Her recount of her father's reaction to her acceptance into STEM School, which entailed him remarking that it was a "'rare opportunity'" and that she needed to "'take it and run with it'", resonates with Hogan and Brown's assertions that families seek to enhance the market value of their children, and specifically according to the logic of neoliberal political rationality. Participant 8 expresses concordantly that "it's … very clear that this is a lucky opportunity". Participant 1's account also seems to indicate that her family deems STEM literacy as a primary form of symbolic capital that one needs to "get ready for life" and thus explains why they are "pushing" her. Her statement that "in life everything is not fair" speaks to her understanding of the precariousness of life under capitalism. Participant 18's account appears to underscore the lengths to which families will go to secure their children's market purchase, revealing that although she "kind of" enjoys math and is "just really bad [at science]", she "didn't choose [STEM School] and "was forced to come here". The extent to which families consider attendance at STEM School to be a means for their children's very economic survival highlights the competitiveness of the market, entrenchment of neoliberal political rationality, and rendering of youth into human capital.

Evidence of the student as human capital and walking firm arises in several other of the participants' accounts. For instance, Participant 6 comments on the need to have the STEM disciplines down, even though they are more challenging. The idea of "needing to have STEM down" elicits the notion of having to acquire STEM literacy as a form of symbolic capital in an uncertain marketplace. Participant 17 admits that even though she wants to be a counsellor, she will "just stick to STEM" for now, a sentiment that evokes the image of STEM education as a life raft in economically uncertain seas. Participant 13 makes an explicit connection between STEM education and the marketplace in her account, asserting that STEM education is "very beneficial" because it will ultimately allow the "advanced" person to "get the job you want" in a society evolving toward technology and engineering. Participant 11 also comments on the important status of the STEM disciplines in the current milieu, but tellingly in contrast to the humanities. She states that though English and social studies are "still important", they are "kind of lower than the science and the math" and that science and math are "what's really important". Participant 22 goes so far to explain that she is "more of an English and arts type of person than math and science", but that she must take her courses "because it's math", seemingly implying, à la Hacker, that mathematics is an inexorable hurdle in the student's race to a career. Her account is particularly arresting because she is aware of the "type" of person she is and yet is also cognizant of how her very subjectivity has been subject to reconfiguration according to the logic of a STEM-centric educational system. Participant 19 offers an equally striking, though brief, account of life as human capital when she states that she does not "really understand much about the

STEM program" but how she is "just concentrating on trying to get my grades up". Her statement speaks to just how enveloped she has become within a system of control. Whereas other students find passion in the STEM disciplines, she can only see STEM education as a bare means for academic, and ultimately economic, survival.

Variation in the Experience of STEM Education

While STEM education appears to be a paradigmatic educational manifestation of neoliberal political rationality and governmentality with the capacity as a dominant cultural reform discourse to shape the practices of institutions and beliefs of stakeholders within the educational community in accordance with the norms of state-capitalism, evidence suggests that students' perceptions of STEM education ultimately express a complex relationship to this theoretical reading. The relationship is complex because students' narratives of STEM education are not uniform. While a seemingly minor point, it is important for an analysis that construes STEM education as having hegemonic power. Students experience the phenomenon in different ways, suggesting that they ultimately interpret what it means to them. For many, STEM education provides opportunities for enjoyment, academic and occupational development, and growth. It thus appears that in virtue of their unique interpretations of the phenomenon, students can interrupt its potential for dominant cultural reproduction. This resonates with Robert Bulman's (2015) observation that although film functions as an effective vehicle for dominant culture, viewers retain the capacity to question and interpret its messages in their own ways (Bulman, 2015).

This also resonates with Jean Anyon's (1981) exploration of the nuances inherent to students' experiences of and within the schools she studied and her conclusion that the process of class reproduction is complex and not inevitable. Each school exhibited what she called both "reproductive" and "nonreproductive" aspects of school knowledge that either reified or challenged facets of the status quo (Anyon, 1981, pp. 31 & 32). For instance, she found that in the Working-Class School, reproductive aspects of school knowledge took the forms of students being denied access to a history of working-class struggle and being required to engage in school labor reminiscent of the manual and mechanistic labor of workers in the working-class. On the other hand, productive aspects of school knowledge in the Working-Class School came by way of teachers exercising physical but neglecting ideological control of students (pp. 32 & 33). She explains that working-class students

> were taught very little of the ideology that is central to stable reproduction of the U.S. system, e.g., traditional bodies of knowledge that include the ideologies of an alleged lack of social alternatives to capitalist organization, patriotism and nationalism, faith in one's own chance of 'making it big,' and belief that the economy and polity are indeed designed in the interests of the average man and woman. (p. 33)

She writes that there was even evidence to suggest that some students had given up on these mythologies of Western capitalism (Anyon, 1981).

Broadly speaking, this suggests that the reproduction of capitalism, classes, and class conflict via the inculcation of ideological hegemony is not inevitable. Anyon writes

that, “A social and theoretical implication of the education of the working-class students in this study, then, is that while a reserve pool of marginally employed workers is perhaps assured by modern schooling, ideological hegemony is not” (p. 33). She continues to explain that, “Ideological hegemony is, rather, extremely tenuous, and the working class may be less ideologically secured than some other social groups” (p. 33). She adds that “useful knowledge” for students in the working-class would be “honest ‘citizenship’ education” that could affirm students’ lived experience in the working-class and provide the means, or “the cultural and ideological tools to begin to transform perspicacity into power” (p. 33).

Variation in STEM Educational Policy

Chesky and Wolfmeyer (2015) have also found variation within the STEM educational policy discourse. Early on in their investigation, they claim that, “there is no way for us to clearly gauge what the motives of policymakers are and exactly how the rhetoric found in policy documents matches the varying axiological objectives of STEM education” (p. 4). Later, they remark that policy is always removed from the complexity of life, as “there is always an incoherence to policies since they are by their very nature unable to capture the complexity of reality as such” (p. 53). With respect to what the STEM education policy discourse expresses as an artifact of culture, they write, “Our original conviction before starting the analysis is that there should be cohesiveness to the way modern education conceptualizes STEM subjects, how it is taught, and for what primary purposes its education is believed to be for”, but then concede,

> From a decade of teaching and research experience in mathematics and science education, our intuition is that such cohesiveness is not present in the discourses surrounding both alternative approaches to STEM education and in dominant views as expressed in national policy documents about STEM education. However, after completing the study, we found that cohesiveness is more complex than we had originally speculated in policy reform texts. (p. 53)

Thus, although they do find evidence that the discourse frames content (ontology) as absolutist, pedagogy (epistemology) as authoritarian, and educational aims (axiology) as instrumental to the maintenance of corporate and state power, they also find the discourse to have an unexpectedly modest orientation toward these valences. They construe this finding as a potential advantage for STEM education reformers, however, stating that, "the lack of cohesiveness may not be a drawback at all, but rather, it may open the space for the potential for positive consequences for teachers and STEM learners to explore" (p. 53). More specifically, they identify "transformative epistemology" as an underrepresented facet of, or indicative of a "void" within, the policy discourse and, therefore, a promising avenue for reform (p. 74).

Where Practice Meets Theory

Students' testimonials thus reveal the experience of STEM education to be personal and variable. Alongside Chesky and Wolfmeyer's recognition of heterogeneity in the STEM educational policy discourse, this variability complicates the notion that dominant cultural reproduction through STEM education is inevitable, predictable, or totalizing. Indeed, at the very core of the Vega model (Martin, 1992) is the notion that

society can change as a result of the individual's capacity to think and act feely, unconstrained by the dictates of dominant culture. Students' ideologic plasticity thus speaks to youth as an undetermined political force, capable of either reifying or challenging the status quo. In her acknowledgements section, Wendy Brown (2015) even refers to her son, Isaac, a young adult who is exuberant and open to life, as a source of hope for the future. She writes, "Isaac's fineness of spirit, extraordinary music, and exuberant openness to life counters my despair about the future" (Brown, 2015, p. 13).

At the same time, however, students' recurrent perceptions of STEM education as a means for academic and occupational subsistence lend support to the theoretical critique's overarching contention that neoliberal rationality is real and influential and that STEM education is an outgrowth of a social order in which the demos is subjected to control by the corporate-state. Moreover, while STEM education provided benefits to most participants, it functioned as a form of forced, or illiberal, education for others, denying them opportunities for enjoyment, academic and occupational development, and growth.

After acknowledging that audiences retain the capacity to question the messages they receive through film, Bulman (2015) makes the crucial caveat that, nevertheless, "we do learn what messages our culture chooses to convey in its entertainment and we incorporate these lessons into an understanding of ourselves and our society" (Bulman, 2015, p. 3). Perhaps in a similar way, though students may possess the capacity to reflect upon the messages they receive via educational policy and its influence upon the everyday practices within school, it is also the case that they inevitably incorporate the

implicit injunctions these policies make upon them: how to understand themselves, each other, the world of work, and society writ large. Given, however, that a significant number of students in this study still desire and even depend on STEM education for intellectual, academic, and occupational opportunities, how might we proceed in our thinking about what education in general and STEM education in particular should be?

References

Anderson, J. D., Kantor, H. A., Tyack, D. B., & National Institute of Education (U.S.). (1982). *Work, youth, and schooling: Historical perspectives on vocationalism in American education*. Stanford, Calif: Stanford University Press.

Anyon, J. (1981). Social class and school knowledge. *Curriculum Inquiry, 11*(1), pp. 3-42.

Brown, W. (2015). *Undoing the demos: Neoliberalism's stealth revolution*. New York, NY: Zone Books.

Bulman, R. C. (2015). *Hollywood goes to high school: Cinema, schools, and American culture*. New York, NY: Worth Publishers.

Chesky, N. Z., & Wolfmeyer, M. (2015). *Philosophy of STEM education: A critical investigation*. New York, NY: Palgrave Macmillan.

Hacker, A. (2016). *The math myth: And other STEM delusions*. New York, NY: The New Press.

Martin, R. J. (1992). A model for studying the effects of social policy on education: Gauging the impact of race, sex, and class diversity. *Equity & Excellence*, *25*(2-4), 53-56.

Chapter 6. Avenues for STEM Education

Confronting Antidemocratic Systems

This analysis has attempted to illustrate how notions of what, how, and why we educate youth are tied to the economic, social, and political visions we have for society. Education and educating are deeply political phenomena, and questions of educational reform are inextricable from those of economic, social, and political reform, and vice versa. In the end, reform hinges upon what kind of society is desired, along with what kinds of actions must occur in order to bring about this society. Indeed, George Counts (1978 [1932]) presciently reasoned that schools 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" and keenly enjoined that "our social institutions and practices, all of them, should be critically examined in the light of such a vision" (Counts, 1978, p. 34). If Sheldon Wolin (1988) is right, however, that all of the primary institutions in our society, including "large-scale educational institutions, … institutions of government, major institutions of media and communication, major institutions of a recognizably economic kind … and … large cultural institutions", are "antidemocratic", what can we do to effect social conditions radically different to our own, or those that are truly democratic (Wolin, 1988)?

A Socio-Economic Heuristic

One way to begin this discussion is with an analysis of The Political Compass (2018) organization's political orientation chart. It overlays a political axis and an economic axis to depict four quadrants of political orientation, thus complicating the pervasive binary conceptualization of political ideology that pits "the left" against "the right", consistent with the chart depicted below in Figure 6 (The Political Compass, 2018):

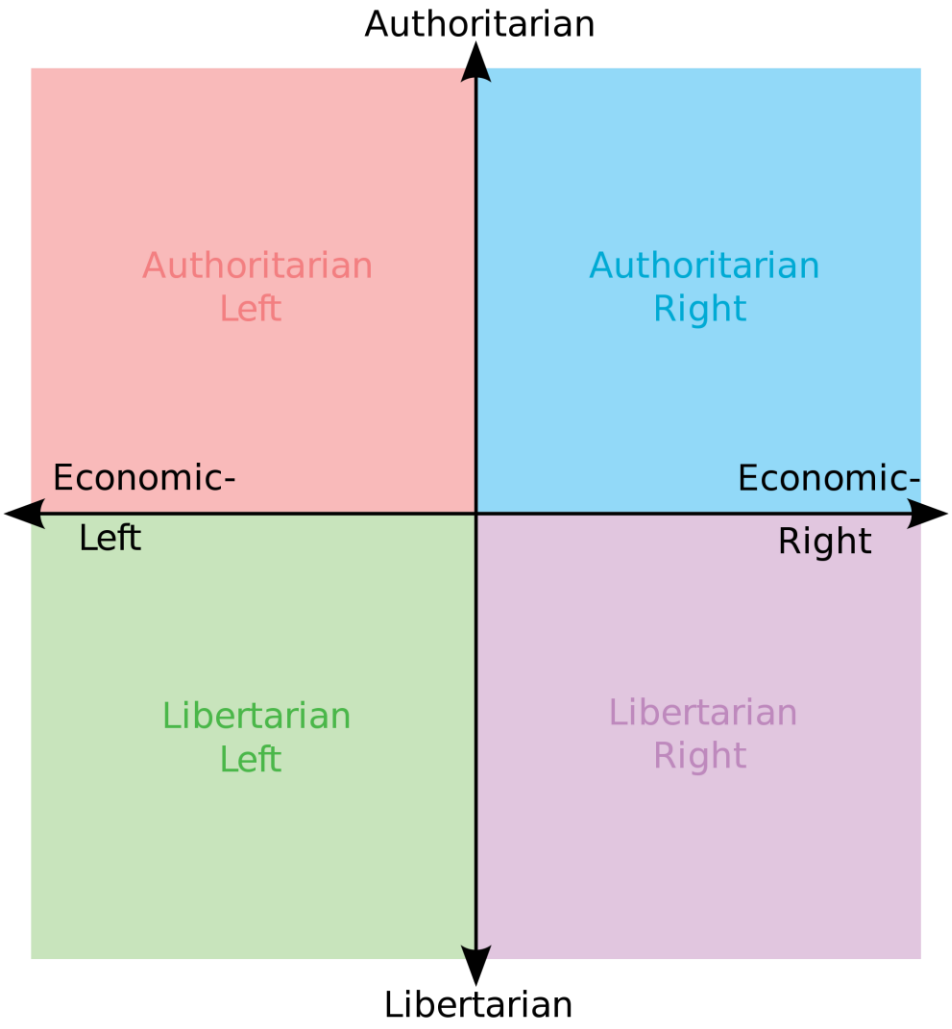

Figure 2 Basic Political Orientation Chart (Wikipedia, 2018)

Although individuals, groups, and polities can be "placed" on the chart, at its most macrocosmic interpretation, the chart can represent a society itself and how this society skews politically and economically. The chart's vertical, or political, axis represents individual liberty and the extent to which it is either realized (libertarian) or controlled (authoritarian) in society. Part and parcel of this parameter is the extent to which the society's governing apparatus, and this manifests today in the form of the state, has the capacity to control individual liberty. At the extreme libertarian end of the political axis, for example, there is no state apparatus within society. Incidentally, this society could be called politically "anarchic", from the Greek word *anarkhos*, meaning "without head or chief" (Dictionary.com, 2018). At the extreme authoritarian end of the political axis, on the other hand, there is a state apparatus within society, and it possesses complete control of the individual. This society could be called politically autocratic or totalitarian.

On the other hand, the economic axis represents the ownership of resources or goods and the extent to which they are either shared (the economic-left) or won (the economic-right) in society. At the extreme economic-left of the economic axis, for example, goods are distributed equally among society's members and there is little to no individual ownership of these goods. Incidentally, this society could be called economically communistic. At the extreme economic-right of the economic axis, on the other hand, individuals attain goods through intense competition. Capitalism, or even ultra-capitalism, is the manifestation of this form of economic orientation (StackExchange, 2018).

Using the political and the economic axes in concert, however, affords more nuanced diagnoses of political orientations for individuals, groups, polities, or even a society itself, according to the four quadrants of the chart: authoritarian-left, authoritarian-right, libertarian-left, and libertarian-right. An authoritarian-left society would, for instance, have a strengthened state and communal distribution of goods. An authoritarian-right society would have a strengthened state and competitive distribution of goods. A libertarian-left society would have a diminished state and communal distribution of goods. And finally, a libertarian-right society would have a diminished state and competitive distribution of goods.

Societies locatable along the axes would also exhibit permutations of state-centeredness and economic competition. For example, an elaborated version of this chart, viewable via StackExchange (2018), displays 29 different orientations and conceives of "liberalism" existing at the chart's point of origin where the political and economic axes intersect, indicating a present but nonintrusive, perhaps "administrative", state with a semi-competitive economic system (StackExchange, 2018).

Commenters have raised concerns about the usefulness of this nuanced interpretation of the more basic Political Compass chart, suggesting that its mathematical "neatness" is incompatible with a messy socio-economic reality (StackExchange, 2018). One criticism has been directed at its portrayal of orientations themselves, particularly its characterization of "Activism" as a socio-economic orientation and how the chart pins it down as an exclusively left- or right-libertarian orientation, when it appears obvious that activism can exist at virtually any point on the chart (i.e., socialist or conservative

activism) (StackExchange, 2018). At the same time, and despite these reasonable criticisms, the chart does provide a useful lexicon for discussing socio-economic orientation. It seems advantageous, in other words, to say that fascism is a right-authoritarian political orientation, or, vice versa, that right-authoritarianism can manifest as fascism.

Left-Libertarianism as a Response to the Status Quo

In pursuit of strategies for countering the status quo and fostering truly democratic social conditions, it would be logical to explore the socio-economic orientation that stands in direct opposition to that of the status quo: right-authoritarianism. In accordance with the political orientation chart, it appears that left-libertarianism is diametrically opposed to right-authoritarianism. But what does left-libertarianism entail? What are its positions on human nature, economic systems, governance, social organization, education, and other fundamental aspects of human life? Does it represent a necessary and sufficient ideological rejoinder to the status quo, or does it provide either an untenable or partially effective response to contemporary social conditions?

First, libertarianism is a general political orientation that supports the diminution of the state in matters of economy and governance. Libertarianism expresses itself as either right- or left-libertarianism depending upon how it calls for the distribution of goods in society: either competitively or communally, respectively. Anarchism appears to represent a more specific and intensified articulation of libertarianism proper, regardless of economic orientation. It also seems to exhibit fundamental tenets. For instance, Mark Wolfmeyer (2012) identifies three key features of anarchism, or "collectivism, fraternity,

and freedom from social hierarchy" (Wolfmeyer, 2012, pp. 39 & 40). Erick Heroux (2010) contends that the fundamental principles of anarchism are "equality, liberty, and solidarity" (Heroux, 2010, p. 23). He also points out his preference for "solidarity" above "fraternity", owing to the latter's "patriarchal 'brotherhood'" (p. 23). And Judith Suissa (2010) reasons that "fraternity and the connected notions of mutual aid, benevolence and solidarity" are some of the fundamental features of anarchism (Suissa, 2010, p. 70). She makes a broader point about an essential feature of anarchism, however, when she explains that anarchism is not necessarily "anti-state or anti-authority, but anti-hierarchy, in the sense that all centralized, top-down structures are to be regarded with suspicion, and small communities favored as the basic units of social organization" (p. 62).

But Heroux also points to the kaleidoscopic nature of anarchism. It seems to entail myriad prescriptions for individuals' relationships to the economy, the state, and each other. He writes that despite the urge to consolidate the various interpretations of anarchic thought into an authoritative definition, perhaps in true anarchic form, theoretical nuance prevails. The following is his diagnosis of the variation within anarchism, quoted at length:

> Certainly anarchism is against domination – but then some anarchists believe in god or in the benefit of parental authority over their children. Others do not. Certainly anarchism is anti-State. Still, some anarchists argue that since transnational corporations are in many cases more powerful than the State, it would then behoove us to modulate this anti-state position to be more practically tactical in approaching social crises where the State can regulate and ameliorate

> some of the abusive practices of capitalism. The main tradition of anarchism was anti-capitalist and even communal. Yet some anarchists support free enterprise and even individualism. Most are modernist, but some are primitivist. Some anarchists are pacifist, while others practised 'propaganda by the deed' with Molotov cocktails and more. Among the latter, some believe that violence is only to be applied against property but not against persons, while others traditionally practised assassination. Some anarchists believe in gradual reform, others in sudden revolution, while others reject both reform and revolution in favour of rebuilding the social fabric from an outside position, or perhaps inside out with alternative services, groups, and practices. (Heroux, 2010, p. 28)

In this description, Heroux thus alludes to the two valences anarchism can take: a right-libertarian or left-libertarian orientation, the latter also referred to as "social-anarchism". Although both orientations are anarchic in the sense that they are libertarian ideologies and thus call for minimal to no state or governmental control over the political and civic lives of individuals, they differ in the sense that the former leans toward the economic right and calls for a competitive distribution of goods in society, whereas the latter leans toward the economic left and calls for the increased to complete communal distribution of goods in society. Right-libertarian anarchism thus promotes a deregulated, free-market-based, competitive, and individualistic socio-economic order, while left-libertarian anarchism, or social-anarchism, promotes communistic economic systems and directly democratic and cooperative forms of governance.

Social-anarchism also seems to express itself further in corollary ideologies. For example, anarcho-syndicalism is a social-anarchic ideology that advocates for workers' rights and the ultimate worker-ownership of the means of production within a non-capitalist, production unit-based conceptualization of the economy (The Editors of Encyclopaedia Britannica, 2018). Philosopher Noam Chomsky is one notable proponent of anarcho-syndicalism. Anarcho-primitivism is another social-anarchic ideology that holds that modern civilization and technological advancements result in perversions of the human condition and calls for a return to hunter-gatherer forms of economy, or "wilding", to restore the natural balance to human life (Dvorsky, 2014). Philosopher John Zerzan is one notable proponent of this ideology.

For the purposes of this inquiry, I have decided to focus on the potentialities of left-libertarian anarchism as opposed to those of right-libertarian anarchism. It seems to me that social-anarchism moves us further away from, and toward a better critical vantage of, the realities of the right-authoritarian status quo. For example, there is nothing inherent to right-libertarian anarchism that would preclude the embrace of capitalism. Because it seeks the diminution of the state for matters of the free-market, given the push in today's milieu to deregulate corporate power, the practice of right-libertarian anarchic principles could portend disastrous consequences for the poor and working-class. Contrarily, social-anarchism is intrinsically dubious of practices that foster social and economic inequity and thus seeks egalitarian social conditions.

Social-Anarchist Education

In her study of anarchism and anarchist education, Suissa (2010) also focuses on the nature and potentialities of social-anarchism as opposed to right-libertarian anarchism. To argue for the viability for social-anarchism within society today, she contends that already embedded within any given population are the seeds for social-anarchic life. Human beings consistently demonstrate that they are capable of cooperation, mutual aid, kindness, compassion, and nonhierarchical socialization and organization. And contrary to the perennial criticism that anarchism hawks an undeliverable social utopia to the masses, 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. Heroux takes a similar stance on the realization of an anarchic society within the status quo and suggests that due to the Internet and the fluid, non-hierarchical communities it has engendered, there is reason to believe that a very real and substantive anarchic society has emerged under our very noses (Suissa, 2010; Heroux, 2010).

Suissa also makes the case that education is a vital component of social-anarchism, responsible for cultivating within society's members the kinds of moral dispositions requisite for the maintenance of a nonhierarchical, decentralized, stateless, and communally-governed society. Moreover, within social-anarchist education, the distinction between the putative means and ends of education collapses. In this vision, the doing of education is the fulfillment of the kind of society it seeks to bring about. She 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)

Suissa also makes a crucial distinction between anarchic and liberal education. First, however, she explains that they are quite similar. The anarchic vision of education is, essentially, liberal in the sense that it is egalitarian in nature, valuing learners' autonomy and equality. Liberal education differs from anarchic education, however, in the sense that the former takes for granted, and consequently never takes issue with, the existence of the liberal state. Suissa asks, "Why, then, does the notion of 'anarchist education' seem, at best, laughable and, at worst, threatening, from a liberal point of view? I would argue that the reason this is so is because 'liberal education' has, in recent years, become synonymous with education in a liberal state" (p. 129). Education within social-anarchism, or "integral education", does not assume the a priori existence of the liberal state and seeks, in fact, to move beyond it (p. 80).

On the history of integral education, Suissa explains that, "Kropotkin's analysis of capitalist industrialized states and their inherent inequalities convinced him that it is the capitalist system itself which divorces manual work from mental work and this creates the false dichotomy between the two and the associated inequalities in social status," and adds that, "The only way to break down these divisions was to provide an education in

which, in the words of Proudhon, 'the industrial worker, the man of action and the intellectual will all be rolled into one'" (p. 103). "Thus the notion of integral education involves," she explains,

> more than just a breaking down, at the practical level, of the traditional liberal-vocational distinctions; it does not propose, that is, merely to ensure that all children leave school with a useful trade and appropriate theoretical knowledge so that they may become fully participating members in the productive economy. The theoretical assumptions behind this notion are, first and foremost, political. Integral education programmes along these lines were seen as an essential element of educational experiments such as those of Paul Robin, in France, where the school was intended to create an environment embodying a commitment to social equality and the belief that communities run on principles of co-education, freedom from coercion, respect for the individual child and self-government could form the vanguard for the socialist revolution. (p. 104)

Suissa does note, however, that there is a distinction between integral education within a state-based compared to a stateless society (p. 114). In the former, integral education would require the means by which to subject the dominant system to critique. She explains,

> Thus the school, for anarchist educators, is seen primarily as a microcosm of one of the many possible forms of anarchist society; an experiment in non-hierarchical communal forms of human interaction where, crucially, alongside a rigorous critique of existing capitalist society, the interpersonal relationships which

> constitute educational interaction are based on the normative role assigned to the human qualities of benevolence, mutual aid and social cooperation. (p. 110).

But in the emergent latter, integral education would serve to safeguard the conditions necessary for a continually experimental, stateless society. She states,

> even if the state is successfully dismantled, given the anarchist commitment to perfectibility and to constant experimentation, and bearing in mind the contextualist conception of human nature, it is important for the community to continue to provide an education which maintains a critical attitude towards existing practices and institutions and fosters attitudes of fraternity and mutual aid. (p. 115)

Social-Anarchism and STEM Education

Three years prior to the publication of *Philosophy of STEM Education*, Mark Wolfmeyer (2012) had investigated how mathematics as a "knowledge" could be adapted 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 the three fundamental values of anarchism he identifies, or "collectivism, fraternity, and freedom from social hierarchy" (Wolfmeyer, 2012, pp. 39 & 40).

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. Although he concedes that his proposals are offered for an educational program within an already, or newly, stateless milieu, he imagines how anarchist mathematics could function within a state-based educational program. It should 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 be able to be discarded if students and educators decide that it is not worthwhile.

In a stateless society, it would thus seem that the natures, purposes, and combinations of the academic disciplines would be contingent upon the society's members' needs. It is conceivable that members of a stateless society would see value in traditional conceptions of science, technology, engineering, and mathematics. One can imagine, for example, that even within a stateless society, there would be pressing needs for such things as physics, computing, infrastructure, and geometry. Building a bridge over a river, for example, would require the careful and cooperative application of physics, computer simulations, bridge design, and geometry. So, it is certainly conceivable that members of a stateless society would see value in associating science, technology, engineering, and mathematics together for the purposes of various communal tasks and would thus teach the disciplines together to prepare their members for such applications.

But it also appears that within a stateless society, a problem itself would dictate the need to assemble these and any other disciplines together. As soon as disciplines are brought together for a problem, they could just as quickly be dissolved into other permutations for subsequent problems. Despite its catchy title, STEM education as "STEM education" would not seem to have any intrinsic, cohesive purpose, and thus any consequent hegemony, in such a society. It is just as conceivable that "STEP", or science, technology, engineering, and philosophy, could be needed for a particular problem. Though not anarchists, John Dewey (2012) and Andrew Hacker (2016) have already shown that academic hierarchies like STEM education can and perhaps should be destabilized and reimagined (Dewey, 2012, p. 254; Hacker, 2016, p. 11).

It appears, therefore, that STEM education could exist within a stateless society, but neither incidentally nor necessarily within the state- and capitalist-based form to which we have become accustomed at the turn of the millennium. Removing STEM education from this logic appears to render the phenomenon contingent and open to possibility. Extricated from the statist strictures of modern institutions, the traditional disciplines could take on new, unbridled, and interpolated forms. Biology, chemical engineering, and calculus, for instance, could find new expressions and meanings if amalgamated with art, dance, and dramatics. Thus, although the interpretations and applications of the disciplines in a stateless society would be indefinite, it appears they would be far less disciplined, indeed.

A Critique of Social-Anarchism

Left-libertarian anarchism, with its de-emphasis on and even disavowal of state power and capitalism and emphasis on communal governance and collectivism, thus seems to be a logical and even promising option to consider for challenging the status quo and its attendant educational proposals and programs. But what are its weaknesses? Is it, by itself, a sufficiently adequate ideological platform from which to challenge the status quo? And if not, to what extent and in what ways could and should it be supplemented in the pursuit of democratizing current social conditions?

Despite his decades-long commitment to left-libertarian aims, Noam Chomsky (2016) himself has dismissed the idea that the dissolution of the liberal state is a viable strategy for egalitarian socio-economic change. In a 2016 interview, he considers the following proposition: that to check corporate power it is better to abolish than strengthen the state because corporations have effectively hijacked it; strengthening the state would, ipso facto, strengthen corporate power.

He sharply dismisses this proposition by arguing that it cannot be a "better" strategy than others for dealing with corporate tyranny because, simply, "It's not a strategy" (Chomsky's Philosophy, 2016). He suggests that such a proposal is the stuff of the aloof academic seminar, akin to blithe proclamations for peace and justice, neither cognizant of the complexity of the socio-economic reality within which we find ourselves, nor considerate of the disastrous consequences that could result from its aim being sought. He suggests that its serious consideration is a "gift" to the corporate class

because it poses no feasible alternative to the current "corporate-state nexus" (Chomsky's Philosophy, 2016).

He reasons that abolishing the state would perhaps be an option if we could rely upon a national network of worker-run collectives in lieu of the state, but because such an infrastructure does not currently exist, we have no other choice but to turn toward state structures for services, governance, education, and order, at least in the short-term. He thus reminds us that modern life is delicately interwoven with state structures, and that without the state, the present world would collapse. Instead, he enjoins anarchists working today to work within the structures of the state to address the immediate needs of the people, citing health care reform as one practical and productive arena for contemporary anarchist activism (Chomsky's Philosophy, 2016).

Toward the end of the interview, Chomsky does indicate that a short-term turn toward the utilization of the state in social reform movements could be commensurate with long-term social-anarchist aims, including a possible gradual shift away from the state. He thus proffers a crucial distinction between aims and strategies. Strategies that appear to conflict with aims could nevertheless be necessary for their fruition. For instance, social-anarchists may need to refrain from disavowing the very structures reformers need to confront extant social and educational problems and instead, paradoxically, work to reform and humanize them before considering their diminution.

Robert Gordon (2016) offers potential reforms for preschool, secondary, and higher education from a broad and practical economic vantage that could also contribute to national economic growth (Gordon, 2016, pp. 641, 647, & 648). He is a proponent of

preschool programs for all children, but particularly for children from lower SES households. He explains, "Poor children lack the in-home reading, daily conversation, and frequent question/answer sessions so common in middle-class families, particularly those in which both parents have completed college" (p. 647). He adds that, "Effective preschool education is devoted not only to vocabulary and other learning skills, but also to 'character skills such as attentiveness, impulse control, persistence and teamwork.'" (p. 648). Moreover, for reform at the secondary and higher educational levels, he argues that at the outset,

> Preschool comes first, because each level of disappointing performance in the American educational system, from poor outcomes on international PISA tests administered to 15-year-olds to remedial classes in community colleges, reflects the cascade of underachievement that children carry with them from one grade to the next. (p. 648)

Due to the economic and educational inequality that results from school finance being dependent upon property taxes, he calls for a change in the ways schools are funded, from a shift in school finance from local to more statewide sources to ensure parity. He even suggests that, "Ideally, schools serving poor children should have the resources to spend more than those serving well-off children, rather than less at present" (p. 648).

Finally, he comments on students' educational loan debt burdens and the need "to shift student loans to a system of income-contingent repayment administered through the income tax system", a program that could be largely based on Australia's system, which offers a grace period while students are enrolled in college, repayment through the

income tax system “based upon a percentage of taxable income”, payment due dates contingent upon having found employment, and the subsidization of 20 percent of outstanding student debt (p. 648).

Giroux (2013) offers a mix of strategies for egalitarian social change, some of which pertain to the improvement of existing state structures and others of which entail the development of spaces, practices, and ideas outside of existing structures. He writes,

> progressives can explore a variety of options to build coalitions with labor unions, environmental organizations, and public servants in order to develop a broad-based alternative party to push for much-needed reforms, including paid family and medical leave, a new equal rights amendment for women, literacy and civic engagement programs, a guaranteed minimum income, ecological reform, free child care, new finance laws for funding public education, the cancellation of higher education debt for middle- and working-class students, health care programs, and a massive jobs program in conjunction with a Marshall Plan-like program to end poverty and inequality in the United States. (Giroux, 2013)

Ironically, Wolin (2008) points out that the Marshall Plan played a role in the “expansion of state power and managerial expertise”, and that since the Clinton administration, “liberal administrators were unable to sustain much enthusiasm for using state power to promote new social programs or even promoting civil rights” (Wolin, 2008, p. 270). It is thus important to point out that strategies for egalitarian reform can have unintended consequences like the expansion of state power, and that activism within existent

structures, especially from the social-anarchist perspective, must attempt to envisage and even counterbalance such outcomes.

For his own part, Wolin has made suggestions for egalitarian social change that are complementary to Giroux's. He posits that, "Democratic experience begins at the local level" and that "democracy … is dependent upon a politics that is rooted locally, experienced daily, practiced regularly, not just mobilized spasmodically" (p. 291). Although these sentiments resonate with a left-libertarian conception of community governance, he offers a practical position toward the utilization of the state for issues outside of local control. For example, he writes, "that the modern citizenry has needs which exceed local resources (e.g., enforcement of environmental standards) and can be addressed only by means of state power" (p. 291). Perhaps unsurprisingly, neo-Marxist philosopher Slavoj Žižek (Philosopher's Stone, 2016) makes a similar point about the necessity of state power for dealing with such largescale challenges as biogenetics and ecological disasters.

At the same time, Wolin proposes the development of what he calls a "democratic counterelite" of public servants, consisting partly of workers within government and similar to an already existing "corps … among the numerous non-governmental organizations (NGOs) devoted to environmental conservation, famine relief, human rights, AIDS prevention, and other like-minded endeavors" (p. 291). He suggests that these causes are effectual due to their focus on localities and their encouragement of "local populations to take responsibility for their own well-being" (p. 291). He concludes by contending that for local politics to pose a check on the impositions of elites, the

"quality of discussion" within and amongst the demos must be improved, and this entails "the reclamation of public ownership of the airwaves and encouragement of noncommercial broadcasting" (pp. 291 & 292). He adds that the current moment hinges on the extent to which the demos can prevent such "hard-won" democratic practices from disappearing (p. 292).

Brown (2015) offers a sobering, if not despairing, assessment, however, of the extent to which the Left can actually effect change within the neoliberalized corporate-state. She writes that its

> difficulties are compounded by the seduction of such surrender to the overwhelmingly large, fast, complex, contingently imbricated, and seemingly unharnessable powers organizing the world today. Tasked with the already difficult project of puncturing the common neoliberal sense and with developing a viable and compelling alternative to capitalist globalization, the Left must also counter this civilizational despair. Our work on all three fronts is incalculably difficult, bears no immediate rewards, and carries no degree of success. Yet what, apart from this work, could afford the slightest hope for a just, sustainable, and habitable future? (Brown, 2015, p. 222)

In response to Brown's bleak assessment, I would suggest that critical educational work that focuses on "puncturing the common neoliberal sense and … developing a viable and compelling alternative to capitalist globalization" in schools could be one such reason to "hope for a just, sustainable, and habitable future", especially in light of the fact that learners, though in troubling ways influenced by neoliberal rationality, are still

ideologically undetermined and capable of developing beliefs, attitudes, and opinions which could ignite and fan radically democratic social imaginaries. Students' testimonials thus complicate the certitude in the inevitability of dominant cultural reproduction.

A Critique of Social-Anarchist Education

With regard to the viability of social-anarchist education within the constraints of the status quo, Jennifer Logue and Cris Mayo (2009) observe that Suissa neglects to address the efficacy of other related and critical educational frameworks in her analysis. Although generally commendatory toward Suissa's examination of social-anarchism and social-anarchist education, 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. They explain that,

> Perhaps it is the lack of complex analysis of the way in which power operates that accounts for the omission—in anarchist theory itself and in this text—of feminist and anti-racist critical pedagogies from the discussion. But in her analysis of the central role of education in the anarchist vision of alternative ways of living, it seems surprising that the concrete educational strategies of consciousness-raising and problem-posing, tools that grew out of leftist political movements, are not discussed. (p. 162)

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. Logue and Mayo write that,

> Suissa argues that part of anarchism's appeal is that it perceives every educational encounter as a moment of striving and creative experimentation to create something better: 'a certain anti-hierarchical stance not only in model for the ideal society but in patterns of thinking' (p. 150). But by not focusing on the process of education fully enough, anarchism misses a key insight from critical pedagogy: the process of education is itself political. This is perhaps the central difference between anarchism and critical pedagogy. Critical pedagogy seeks to change oppressive social relations in the here and now, and it sees education as central to creating personal and social transformation. (p. 164)

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) also comments on the relationship between social-anarchism and critical pedagogy and calls for their 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, although 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, the authors refrain from fleshing out full theoretical accounts that could combine tenets from both social-anarchist education and critical pedagogy, leaving this work for future scholarship. Logue and Mayo conclude,

> We think this enhanced conversation among critical pedagogy, antiracist pedagogy and anarchist thinking on education can help to show both the

> continued relevance of radical and creative thinking—and to show that anarchist thought has been part of the development of oppositional, critical, collaborative, teaching and learning projects. (Logue & Mayo, 2009, p. 165)

And DeLeon concludes by indicating the pressing need for academics to bridge the gap between theory and practice, to "make radical discourses accessible to those people who need to understand how systems of oppression work" (DeLeon, 2006, p. 89). "This is not going to be an easy task," he warns, "but it is becoming alarmingly urgent" (p. 89).

Chesky and Wolfmeyer's Anarcho-Critical STEM Education

Chesky and Wolfmeyer's (2015) alternative conceptualization of STEM education may stand as a fitting reply to Logue and Mayo's and DeLeon's recommendations, comprehensively integrating aspects of anarchism and critical pedagogy. They organize their conceptualization according to the three philosophical categories of analysis they employed throughout their investigation, ontology (content), epistemology (pedagogy), and axiology (aims of education).

Ontologically, they seek a "post-modern conception of STEM subjects" (Chesky and Wolfmeyer, 2015, 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.

And 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 also point out that presenting the STEM disciplines as aesthetic and transformative is contingent upon the Freirean notion of knowledge as power (p. 92). Ultimately, they frame their alternative conceptualization as revolutionary, but qualify "revolution" in a strikingly anarchic 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).

A Reply to Chesky and Wolfmeyer's Conceptualization

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. Although their alternative conceptualization would likely result in potent appropriations of dominant STEM educational discourses, there appears to be the need for an approach

that more directly confronts hegemonic structures and the problems they wreak. I thus propose that an anarcho-critical conception of 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.

A "state-critical" STEM education would actively and transparently incorporate content and activities that were explicitly critical of capitalism and the state into its lessons, a practice that never emerges in Chesky and Wolfmeyer's account. In this way, it would be more congruent with Count's conception of an educational system that explicitly fosters students, teachers, and the school as agents of socio-economic change. Whereas Chesky and Wolfmeyer call for a conceptualization of revolution that is "a subtle introspective creative process that although happens under the situation as it stands, slowly but surely erupts to change society completely", a state-critical STEM education would seek social and economic change via direct confrontation with the status quo and question the adequacy of the expectation for "slow and sure" social change (Chesky & Wolfmeyer, 2015, p. 93).

Like Chesky and Wolfmeyer's conception, however, a state-critical STEM education would consider the state-capitalist order to be unavoidable in contemporary life. They prudently claim that students' knowledge of fractions as a mathematical skill is not itself harmful, for example, but that a lack of an understanding of fractions could be detrimental to their future academic and occupational prospects (p. 91). State-critical

STEM education would similarly concede that students and workers depend upon the current system for survival and would identify the ways in which it could prepare future citizens and workers for facing political and economic eventualities, including interacting with representatives of the state, like police officers; making informed choices within a majority-rule system; preparing for, finding, and maintaining gainful employment; paying taxes; and other activities required for navigating a state-based and meritocratic society (Suissa, 2010).

But state-critical STEM education's tolerance of the state would be strategic. At the risk of stretching a metaphor, features of the state, such as policing, political representation, the renting of one's labor to corporations, and taxation, would be treated as "crutches" to a democratically-incapacitated demos. Without ever having had the opportunity for authentic, directly democratic decision-making, the demos must limp forward on these ultimately compromised supports. Police officers are discriminant in their treatment of their communities; political representation is becoming further insulated from the popular will by the Electoral College and unlimited campaign financing; work and labor are quickly becoming automated; toxic, part-time, benefit-free jobs are becoming the norm in our gig economy; and the process of taxation has resulted in the siphoning of resources away from the poor and the protection of the wealthiest income earners in the country.

State-critical STEM education would thus permit state-capitalism insofar as tolerating it in the short-term would allow for a rehabilitation of the social institutions upon which the demos has been forced to rely. It would, for example, enjoin schools to

critique the weaknesses in the foundations of the state and envisage ways in which to cultivate the principles and practices of compensatory justice and humane treatment within social institutions. After having had egalitarian and recuperative state-based support, a nourished and strengthened demos might then someday be able to shake off its prescribed modes of representation and realize the social-anarchist vision of cooperative self-governance. In this sense, and perhaps paradoxically, a viable way out of the state might entail having to progress through increasingly functional yet communally empowering instantiations of it.

Philosophically, therefore, state-critical STEM education would be both critical pedagogical and social-anarchic: It would employ critical pedagogical methods as means for the ultimate realization of social-anarchic ends. As itself a type of pedagogical crutch, it would serve as a transient and not a programmatic "end". It would be conversional, transitional, and conditional. It would serve to convert existent STEM educational programs into those that could play a role in shifting the aims and practices of social, economic, and educational edifices toward those of the libertarian-left, thus being commensurate with long-term social-anarchist aims in the way Chomsky has described. And in this sense, state-critical STEM education would be a transitional educational program, hovering between a reality dictated by state-capitalism and its attendant educational initiatives and a potential future characterized by integral educational and social-anarchist ideals. State-critical STEM education would thus be conditionally existent upon the extent to which the dominant conceptualization of STEM education, as well as the dominant socio-economic system, pertains. In short, it would be a desired

outcome if egalitarian educational and socio-economic conditions rendered state-critical STEM education completely irrelevant.

Examples of "State-Critical" STEM Education

Below are several ideas for resultant units or courses of study in a state-critical STEM educational program 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 science 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 would create.

"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 in the pursuit of 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, such as the prison-industrial complex and the school-to-prison pipeline, 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 uses of drone technology.

Considerations for "State-Critical" STEM Education

One concern for state-critical STEM education is that it could indoctrinate students into specific political ideologies. Perhaps it can be argued, by invoking Martha Nussbaum's (2011) thoughts on capabilities and Claudia Ruitenberg's (2010) views on fostering students' political identification, that educators have the duty to give students

the capability for, but not the injunction to adopt, social and political identification while simultaneously and vigilantly safeguarding and encouraging students' right to dissent to the ideas discussed in class. In this way, a state-critical STEM education could potentially offer students overt critiques of corporate-state hegemony while also avoiding the prescription to adopt particular worldviews.

As indoctrination is an impingement upon and an attempt to control an individual's capacity to form their own thoughts and opinions about a given topic, it strikes at the very heart of social-anarchism's raison d'être: freedom for the individual. Indeed, as an ultimately anarchic educational approach, state-critical STEM education would prioritize the maintenance of student autonomy. Due to the critical purposes of state-critical STEM education, however, it seems that guarding against student indoctrination would be a consistent concern for educators within this approach.

Part and parcel of this respect for student freedom would also be a fundamental regard for student equality. Heroux (2010) points to one of the pedagogical implications of the anarchic injunction to take equality seriously. He states,

> What if we, regrettably for the first time, began to take seriously the principle of equality in as many situations as possible. What if for instance, we assumed that students really are equal to their teachers – just as a thought experiment and then perhaps as praxis … The political and pragmatic assumption of equality can lead to classroom experiences where this equality is manifested, that is, where students can teach themselves just as much as the teacher. (Heroux, 2010, pp. 26 & 27)

His quote brings to mind schools like Summerhill School in the United Kingdom and Sudbury Valley High School in Massachusetts, in which there have emerged authentic and sustained attempts to treat students, their interests, and their opinions with utmost regard. One of the checks against indoctrinal interpretations of state-critical STEM education could be, therefore, a regard for students as equal, rational, and capable human beings who possess the inalienable right to question, deny, and even protest the ideas discussed in class.

The approach should also guard against turning students wholly critical of all state and economic systems and, thus, overly cynical. Although state-critical STEM education would offer students opportunities for learning about and critiquing existent power structures, it should strive to provide students with concrete means for improving these structures, in line with Chomsky's injunction that anarchists working today focus short-term efforts on strengthening a state that is responsive to its people, in part as an instrument for defending against unchecked corporate tyranny (Chomsky's Philosophy, 2016).

In this vein, students and teachers could engage in community service projects in conjunction with federal programs such as Head Start and Upward Bound. Fundraising to provide curricular materials for both programs could be one such service project; volunteering time for tutoring in Upward Bound's Summer Enrichment Institute could be yet another. But coinciding with efforts to improve the efficacy of such state-based compensatory justice initiatives could be a critical analysis of the state's historical complicity in the practice of redlining and how racist banking and city planning practices

have played a significant role in the very creation of the lower socio-economic status communities that students and teachers are striving to assist through federal programming.

Another concern for this educational approach is the age at which it could and should be taught. It is difficult to predict how students at earlier high school, middle school, and elementary levels would react to the various ideas it would seek to explore. It is obvious that the courses annotated above would have to be amended in significant ways to be apposite for earlier grades. Suffice is to say, incorporating these courses at levels lower than that of the advanced high school level would be discretionary. In line with the injunctions to avoid student indoctrination and respect student autonomy, state-critical STEM educational classes might also be offered as elective options.

References

Brown, W. (2015). *Undoing the demos: Neoliberalism's stealth revolution*. New York, NY: Zone Books.

Counts, G. S. (1978). *Dare the school build a new social order?*. Carbondale, IL: Southern Illinois University Press.

Dewey, J. (2012). *Democracy and education*. Middleton, DE: Simon & Brown.

[Chomsky's Philosophy]. (2016, May 7). *Noam Chomsky on abolishing the state*. [Video File]. Retrieved from https://www.youtube.com/watch?v=nBFiMn1Ecjg

DeLeon, A. P. (2006). The time for action is now! Anarchist theory, critical pedagogy, and radical possibilities. *Journal For Critical Education Policy Studies (JCEPS), 4*(2), 73-94.

Dictionary.com. (2018). Anarchic. Retrieved from http://www.dictionary.com/browse/anarchic

Dvorsky, G. (2014). Why do the anarcho-primitivists want to abolish civilization? *Gizmodo Media Group*. Retrieved from https://io9.gizmodo.com/why-do-the-anarcho-primitivists-want-to-abolish-civiliz-1633477541

Gallagher, M. (2010). Are schools panoptic?. *Surveillance & Society*, *7*(3/4), 262-272. Retrieved from http://ojs.library.queensu.ca/index.php/surveillance-andsociety/article/viewFile/4155/4158

Giroux, H. A. (2013). Challenging casino capitalism and authoritarian politics in the age of disposability. *Monthly Review Press*. Retrieved from http://www.truth-out.org/news/item/17176-henry-a-giroux-americas-education-deficit

Gordon, R. J. (2016). *The rise and fall of American growth: The U.S. standard of living since the Civil War*. Princeton, NJ: Princeton University Press.

Hacker, A. (2016). *The math myth: And other STEM delusions*. New York, NY: The New Press.

Heroux, H. (2010). PostAnarchia repertoire. *Anarchist Developments in Cultural Studies*, *1*(1), 19-20.

Logue, J., & Mayo, C. (2009). Imagining the future: What anarchism brings to education. *Journal Of Philosophy Of Education*, *43*(1), 159-165.

Nussbaum, M. (2011). *Creating capabilities: The human development approach*. Cambridge, MA: The Belknap Press of Harvard University.

[Philosopher's Stone]. (2016, August 1). *Zizek on the shortcomings of anarchism and anarcho-syndicalism*. [Video File]. Retrieved from https://www.youtube.com/watch?v=uwUDEOAxLlc

Ruitenberg, C. (2010). Conflict, affect and the political: On disagreement as democratic capacity. *In Factis Pax*. 4(1), 40-55.

StackExchange. (2018). How accurate is this political orientation chart? Stack Exchange Inc. Retrieved from https://politics.stackexchange.com/questions/11669/how-accurate-is-this-political-orientation-chart

Suissa, J. (2010). *Anarchism and education: A philosophical perspective*. Oakland, CA: PM Press.

The Editors of Encyclopaedia Britannica. (2018). Syndicalism. *Encyclopædia Britannica, Inc*. Retrieved from https://www.britannica.com/topic/syndicalism

The Political Compass. (2018). About the political compass. PACE NEWS LTD. Retrieved from https://www.politicalcompass.org/analysis2

Wikipedia. (2018). Political chart. Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/File:Political_chart.svg

Wolfmeyer, M. (2012). In Defense of Mathematics and its Place in Anarchist Education. *Educational Studies*, 48(1), 39-51.

Wolin, S. S. (2008). *Democracy incorporated: Managed democracy and the specter of inverted totalitarianism*. Princeton, NJ: Princeton University Press.

Wolin, S. S. (1988). Sheldon Wolin: The state of democracy. *Moyers & Company*. Public Square Media, Inc.

Conclusion

Review

What, in the end, is STEM education? At the very least, I hope to have problematized Alexandra Ossola's (2014) assertion that STEM education is simply "justified" (Ossola, 2014). Rather, STEM education remains a complicated phenomenon, a decades-old site of ideological and political struggle. Consequently, mainstream STEM educational proposals can propagate conceptions of educational excellence concomitant to nationalist and capitalist logics. They can also end up being illiberal, figuring the student first and foremost as a future worker for the marketplace instead of as a growing human being with passions and anxieties.

Although dominant conceptualizations of STEM education are emergent from and contingent upon the mechanisms of the current system, however, there is no reason to believe that STEM education is itself necessarily or inherently beholden to any ideological prescriptions. Rather, the idea seems to be surprisingly malleable and serviceable for critical and egalitarian aims. For example, there is no question that STEM education can be retheorized in accordance with progressive and even Deweyian conceptions of education.

In this dissertation, however, I have focused on the extent to which STEM education is conducive to the maintenance of the corporate-state and American

imperialism and the cultivation of students as economized beings and, thus, consequent avenues for reform. An understanding of the corporate-state apparatus as a series of social institutions that perpetuate the norms, values, and standards of dominant culture within a hierarchy of influence helped to direct the focus of this analysis upon students' lived experiences as an essential element in a philosophical analysis of STEM education.

After considering the thoughts, hopes, and fears of students within a STEM-focused college-preparatory school, I argued that their narratives indicated socialization into dominant culture. At the same time, however, I concluded that students' heterogenous responses suggested that they were ideologically undetermined and that critical educational intervention could possibly interrupt hegemonic enculturation and foster political subjectification. After all, at the very heart of the Vega model is the notion that individuals can retain and reclaim autonomy and change dominant culture as a result.

I subsequently turned to left-libertarianism as a potential socio-economic orientation for countering the effects of a right-authoritarian status quo and STEM education as an auspicious vehicle for anarcho-critical conceptualizations of education. I tempered this pursuit, however, by considering scholars' misgivings about the plausibility of social-anarchism for a state-based reality. As Noam Chomsky has pointed out, there is a difference between aims and strategies, and strategies that may be necessary for moving the status quo closer to a desired state of affairs may conflict with one's aims. Regardless of the ways in which STEM education evolves in the approaching years, for example, it should value its adherents' interests and needs, even if this means tolerating the demands and expectations of state-capitalism, at least in the short-term.

After reviewing conceptualizations of education that attempted to integrate social-anarchist and critical pedagogical methodologies, I considered Nataly Chesky and Mark Wolfmeyer's social justice-orientated conceptualization of STEM education as a promising avenue for reform, but concluded that its proclivity for social-anarchism over critical pedagogy impeded its ability to offer students opportunities for learning explicitly about and questioning elements of the corporate-state and American imperialism. To redress this, I proposed a "state-critical" conception of STEM education that took advantage of critical pedagogy's capacity for direct critical engagement with elements of the power structure. I then envisioned state-critical STEM education in the form of several upper-high school or undergraduate courses and concluded by discussing the conceptualization's potential shortcomings.

Outlook

There is no doubt that in today's political climate, egalitarian reform resembles Sisyphus' stone. The Trump administration's voracious appetite for privatizing public spaces like Bears Ears National Monument, Scott Pruitt and his ilk's concerted assault on the existence of environmental regulation for corporate profit, and Betsy DeVos' refusal to grant loan forgiveness to students whom have been defrauded by for-profit colleges are just a few of the many challenges to face.

At the same time, there have been developments in politics and educational scholarship that inspire hope for those of us interested in left-libertarian social reform. Bernie Sanders has catapulted a discussion of left-libertarianism qua democratic socialism into the mainstream of American politics, and we now see his acolytes,

including rising star Alexandria Ocasio-Cortez, achieving considerable success on the political scene. Movements like Black Lives Matter and #MeToo signal the continued potency and potential of grassroots political activism, casting doubt on the rifeness of homo oeconomicus and the fixity of dominant culture. And in the educational arena, scholars like John Bencze and John Lupinacci are theorizing STEM education in the context of a worsening climate crisis.

Ultimately, I have attempted to show that if we are to cultivate citizens as political beings and preserve the vestiges of liberal democracy, we must work to counter, reform, and even replace facets of the status quo. As it was George Counts' hope that teachers mobilize to fight an unjust socio-economic system, it is my hope that at a time of impending social, economic, and ecological catastrophe, educators wield their influence toward effecting peace, justice, and sustainability in our world.

Bibliography

Anderson, J. D., Kantor, H. A., Tyack, D. B., & National Institute of Education (U.S.). (1982). *Work, youth, and schooling: Historical perspectives on vocationalism in American education*. Stanford, Calif: Stanford University Press.

Anyon, J. (1981). Social class and school knowledge. *Curriculum Inquiry*, *11*(1), pp. 3-42.

Anyon, J. (1980). Social class and the hidden curriculum of work. *Journal of Education*, *162*(1), 67-92.

Barrett, T. G. (2012). Between citizens and the state: The politics of American higher education in the 20th century/*More than science and Sputnik: The National Defense Education Act of 1958*. *American Educational History Journal*, *39*(1/2), 251-263.

Bourdieu, P. (1994). Rethinking the state: Genesis and structure of the bureaucratic field. *Sociological Theory*, *12*(1), 1-18.

Brown, W. (2015). *Undoing the demos: Neoliberalism's stealth revolution*. New York, NY: Zone Books.

Bulman, R. C. (2015). *Hollywood goes to high school: Cinema, schools, and American culture*. New York, NY: Worth Publishers.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. Arlington, VA: National Science Teachers Association.

Chesky, N. Z., & Wolfmeyer, M. (2015). *Philosophy of STEM education: A critical investigation*. New York, NY: Palgrave Macmillan.

[Chomsky's Philosophy]. (2016, May 7). *Noam Chomsky on abolishing the state*. [Video File]. Retrieved from https://www.youtube.com/watch?v=nBFiMn1Ecjg

Counts, G. S. (1978). *Dare the school build a new social order?*. Carbondale, IL: Southern Illinois University Press.

Cremin, L. A. (1961). *The transformation of the school: Progressivism in American education, 1876-1957 / Lawrence A. Cremin*. New York, NY: Alfred A. Knopf.

DeLeon, A. P. (2006). The time for action is now! Anarchist theory, critical pedagogy, and radical possibilities. *Journal For Critical Education Policy Studies (JCEPS), 4*(2), 73-94.

Dewey, J. (2012). *Democracy and education*. Middleton, DE: Simon & Brown.

Dictionary.com. (2018). Anarchic. Retrieved from http://www.dictionary.com/browse/anarchic

Drew, D. E. (2011). *STEM the tide: Reforming science, technology, engineering, and math education in America*. Baltimore, MD: Johns Hopkins University Press.

Dvorsky, G. (2014). Why do the anarcho-primitivists want to abolish civilization? *Gizmodo Media Group*. Retrieved from https://io9.gizmodo.com/why-do-the-anarcho-primitivists-want-to-abolish-civiliz-1633477541

Gallagher, M. (2010). Are schools panoptic?. *Surveillance & Society, 7*(3/4), 262-272. Retrieved from http://ojs.library.queensu.ca/index.php/surveillance-andsociety/article/viewFile/4155/4158

Giroux, H. A. (2013). Challenging casino capitalism and authoritarian politics in the age of disposability. *Monthly Review Press*. Retrieved from http://www.truth-out.org/news/item/17176-henry-a-giroux-americas-education-deficit

Gordon, R. J. (2016). *The rise and fall of American growth: The U.S. standard of living since the Civil War*. Princeton, NJ: Princeton University Press.

Hacker, A. (2016). *The math myth: And other STEM delusions*. New York, NY: The New Press.

Heroux, H. (2010). PostAnarchia repertoire. *Anarchist Developments in Cultural Studies, 1*(1), 19-20.

Johnson, S. (February 5, 2015). 'Wisconsin Idea' was rewritten per Walker's drafting orders. *Wisconsin Public Radio*. Retrieved from http://www.wpr.org/wisconsin-idea-was-rewritten-walkers-drafting-orders

Jolly, J. L. (2009). The National Defense Act, current STEM initiative, and the gifted. *Gifted Child Today, 32*(2), 50-53.

Kaestle, C. F. (1991). *Literacy in the United States: Readers and reading since 1880*. New Haven, CT: Yale University Press.

Katz, M. B. (1987). *Reconstructing American education*. Cambridge, Mass: Harvard University Press.

Katznelson, I., & Weir, M. (1985). *Schooling for all: Class, race, and the decline of the democratic ideal*. New York: Basic Books.

Kliebard, H. M. (1995). *The struggle for the American curriculum, 1893-1958*. New York, NY: Routledge & Kegan Paul.

Kukathas, C. (2014). A definition of the state. *University of Queensland Law Journal*, *33*(2), 357-366.

Logue, J., & Mayo, C. (2009). Imagining the future: What anarchism brings to education. *Journal Of Philosophy Of Education*, *43*(1), 159-165.

Martin, R. J. (1992). A model for studying the effects of social policy on education: Gauging the impact of race, sex, and class diversity. *Equity & Excellence*, *25*(2-4), 53-56.

Miller, S. (2014). Social institutions. *The Stanford Encyclopedia of Philosophy*. Retrieved from https://plato.stanford.edu/archives/win2014/entries/social-institutions/

MSNBC. (2012). An excerpt from Michael Sandel's "*What money can't buy*". NBC Universal. Retrieved from http://www.msnbc.com/morning-joe/excerpt-michael-sandels-book

Nussbaum, M. (2011). *Creating capabilities: The human development approach*. Cambridge, MA: The Belknap Press of Harvard University.

Ossola, A. (December 03, 2014). Is the U.S. focusing too much on STEM? *The Atlantic*. The Atlantic Monthly Group. Retrieved from http://www.theatlantic.com/education/archive/2014/12/is-the-us-focusing-too-much-on-stem/383353/

Patton, M. (2013). ATE had role in the naming of STEM. *ATE@20*. ATE Central. Retrieved from https://atecentral.net/ate20/22917/ate-had-role-in-the-naming-of-stem

[Philosopher's Stone]. (2016, August 1). *Zizek on the shortcomings of anarchism and anarcho-syndicalism*. [Video File]. Retrieved from https://www.youtube.com/watch?v=uwUDEOAxLlc

Ruitenberg, C. (2010). Conflict, affect and the political: On disagreement as democratic capacity. *In Factis Pax*. 4(1), 40-55.

Sanders, M. (December 01, 2008). STEM, STEM Education, STEMmania. *Technology Teacher*, *68*(4), 20-26.

Shaughnessy, M. (February 2, 2012). STEM: An advocacy position, not a content area. *Summing Up*. NCTM. Retrieved from https://www.nctm.org/News-and-Calendar/Messages-from-the-President/Archive/J_-Michael-Shaughnessy/STEM_-An-Advocacy-Position,-Not-a-Content-Area/

StackExchange. (2018). How accurate is this political orientation chart? Stack Exchange Inc. Retrieved from https://politics.stackexchange.com/questions/11669/how-accurate-is-this-political-orientation-chart

State of Wisconsin Department of Workforce Development. (2014). Governor Walker proclaims STEM education week in Wisconsin. Wisconsin.gov. Retrieved from https://dwd.wisconsin.gov/dwd/newsreleases/2014/140311_stem_education_week.pdf

Suissa, J. (2010). *Anarchism and education: A philosophical perspective*. Oakland, CA: PM Press.

The Editors of Encyclopaedia Britannica. (2018). Syndicalism. *Encyclopædia Britannica, Inc*. Retrieved from https://www.britannica.com/topic/syndicalism

The Political Compass. (2018). About the political compass. PACE NEWS LTD. Retrieved from https://www.politicalcompass.org/analysis2

U.S. Department of Education. (2016). Science, technology, engineering, and math: Education for global leadership. Retrieved from http://www.ed.gov/stem

Urban, W. J. (2010). *More than science and Sputnik: The National Defense Education Act of 1958*. Tuscaloosa: The University of Alabama Press. Retrieved September 2, 2017, from Project MUSE database.

Wikipedia. (2018). Political chart. Wikimedia Foundation. Retrieved from https://en.wikipedia.org/wiki/File:Political_chart.svg

Wolfmeyer, M. (2012). In Defense of Mathematics and its Place in Anarchist Education. *Educational Studies*, 48(1), 39-51.

Wolin, S. S. (2008). *Democracy incorporated: Managed democracy and the specter of inverted totalitarianism*. Princeton, NJ: Princeton University Press.

Wolin, S. S. (1988). Sheldon Wolin: The state of democracy. *Moyers & Company*. Public Square Media, Inc.

Wong, A. (February 11, 2015). The governor who (maybe) tried to kill liberal-arts education. *The Atlantic*. Retrieved from

http://www.theatlantic.com/education/archive/2015/02/the-governor-who-maybe-tried-to-kill-liberal-arts-education/385366/

Zakaria, F. (March 26, 2015). Why America's obsession with STEM education is dangerous. *The Washington Post*. Retrieved from https://www.washingtonpost.com/opinions/why-stem-wont-make-us-successful/2015/03/26/5f4604f2-d2a5-11e4-ab77-9646eea6a4c7_story.html

Appendix A. A Consolidation of the Theoretical Critique

In this addendum to the dissertation, I will attempt to amalgamate its central theoretical critique into a coherent narrative by referring to Pierre Bourdieu's (1994) analysis of the state as an ideological phenomenon that suffuses into the everyday practices of the public and then concretizing Bourdieu's thoughts by turning to social reconstructionist scholar Renée Martin (1992) and her analysis of Flavio Vega's "Wholistic Model for the Study of Social Policy on Race, Sex, and Class Diversity in Education". After reviewing the model's capacity for illuminating the relationships between class, social institutions, culture, and individual experience, I will amend the model so that it is better able to account for the role of social artifacts, including educational policy documents, in reproducing the norms, values, and standards of dominant culture. After demonstrating how this amended model can be used by applying it to the work of film scholar and cultural critic Robert Bulman (2015), I will proffer a second amended model, expanded to simulate how hegemonic culture flows from corporations as dominant, state-controlling social institutions to subsidiary social institutions like schools and families. This consolidation of the theoretical critique may help to elucidate the interrelatedness of the American system as an imperialist corporate-state wedded to casino capitalism, neoliberalism as a governing form of political rationality, and schools as sites for class exploitation and reproduction.

Consistent with Giroux, Wolin, and Brown's analyses of neoliberalism as a dominant and transmogrifying socio-economic force is Pierre Bourdieu's (1994) analysis of the state and its capacity to naturalize itself in the minds, things, institutions, and practices of the social worlds in which it exists. Bourdieu writes "that one of the major powers of the state is to produce and impose (especially through the school system) categories of thought that we spontaneously apply to all things of the social world—including the state itself" (Bourdieu, 1994, p. 1). He points to the naturalizing power of the state to explain the common resistance to even small changes in school practices, like the amount of time, or "time tables", devoted to different school subjects: He writes that,

> Thus, if the mildest attempt to modify school programs, and especially time tables for the different disciplines, almost always and everywhere encounters great resistance, it is not only because powerful occupational interests (such as those of the teaching staff) are attached to the established academic order. It is also because matters of culture, and in particular the social divisions and hierarchies associated with them, are constituted as such by the actions of the state which, by instituting them both in things and in minds, confers upon the cultural arbitrary all the appearances of the natural. (p. 2)

Resonant with both Kukathas' analysis of the state as a "supreme corporate entity" that, compared to other of society's political associations, is the most "voracious" in its appetite for acquiring both revenue and territory, as well as the previous analyses of neoliberalism's disintegration of public institutions like schools, Bourdieu's analysis of the state also notes its capacity for enacting both physical and symbolic violence on its

population by way of its organization of the most banal facets of human interaction and experience (Kukathas, 2014, pp. 358 & 361; Bourdieu, 1994, p. 3). He writes that, "If the state is able to exert symbolic violence, it is because it incarnates itself simultaneously in objectivity, in the form of specific organizational structures and mechanisms, and in subjectivity in the form of mental structures and categories of perception and thought" (pp. 3 & 4). "By realizing itself in social structures and in the mental structures adapted to them," he continues, "the instituted institution makes us forget that it issues out of a long series of acts of *institution* (in the active sense) and hence has all the appearances of the natural" (p. 4). But how is it that the state becomes so deeply instituted and naturalized within the very minds of the populace?

The Vega Model

Renée Martin (1992) offers a methodology that can elucidate how social institutions influence the individual in the manner Bourdieu describes. In "A Model for Studying the Effects of Social Policy on Education: Gauging the Impact of Race, Sex, and Class Diversity", Martin examines scholar Flavio Vega's (1987) "Wholistic Model for the Study of Social Policy on Race, Sex, and Class Diversity in Education" to make sense of the interrelationships between class, social institutions, culture, and individual experience.

She begins by underscoring the need for ways to discuss race, class, and gender inequality with preservice educators, many of whom are white and middle-class (Martin, 1992, p. 53). She suggests Vega's Venn diagram-based model as an effectual means for isolating and clarifying the concepts essential for understanding inequality: bias,

prejudice, and discrimination. I have reproduced the Vega model in Figure 1 as it originally appeared in Martin's article:

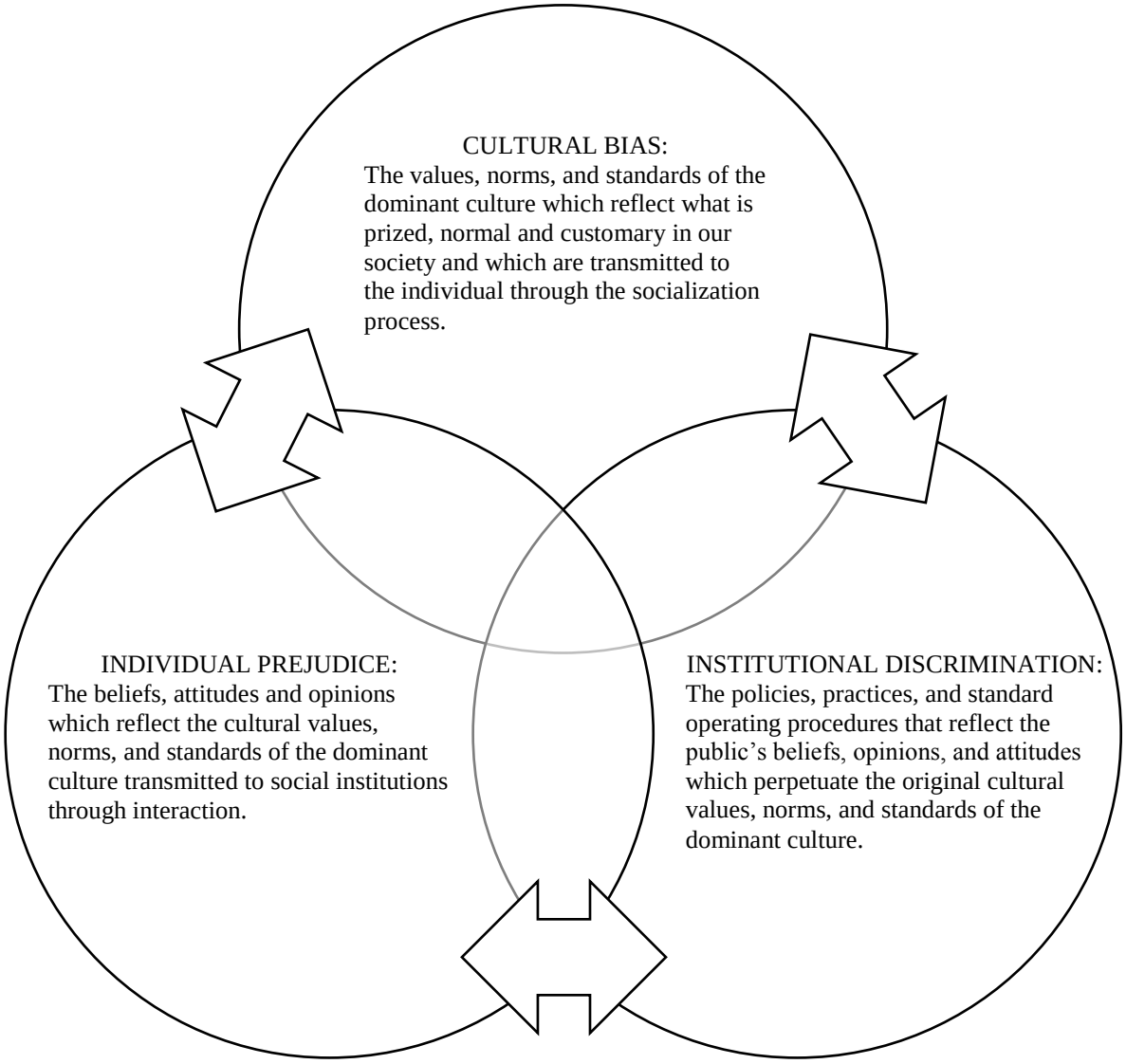

Figure 3 A Wholistic Model for the Study of Social Policy on Race, Sex, and Class Diversity in Education

By assigning the terms bias, prejudice, and discrimination to respective sections of the diagram, the Vega model offers a nuanced and systematic way to discuss social problems. Bias, for example, is a cultural phenomenon. It is comprised of a dominant

culture's "values, norms, and standards" (Martin, 1992, p. 54). Prejudice is an individual phenomenon. It is comprised of an individual's "beliefs, attitudes and opinions" (p. 54). And discrimination is an institutional phenomenon. It is comprised of a social institution's "policies, practices, and standard operating procedures" (p. 54).

The model also illustrates how bias, prejudice, and discrimination interrelate, as depicted by the model's double-headed arrows. Martin offers a concrete, real-world example to illustrate this conceptual fluidity. She writes,

> For example, a teacher who has grown up in a culture that values the concept of being on time may insist that students be punctual, invoking stringent penalties against students who arrive late or hand in late work. The teacher may rationalize the behavior by noting that society expects its future workers to be on time in their jobs. Such assertions are based on limited assumptions about the world of work and are bound by sociocultural expectations *for* certain groups *by* certain groups. Teachers perpetuate the dominant cultural values and rationalize their own behaviors often without considering the implications of those behaviors on the diverse populations they teach. (pp. 53 & 54)

In this anecdote, Martin captures the complex relationships between bias, prejudice, and discrimination. The teacher, once a child, was born into a preexistent culture with specific values, norms, and standards. By maturing and becoming socialized in this culture and amongst its specific values, norms, and standards, she learned what was "prized, normal, and customary" for her peers and her. Martin invokes the concept of punctuality as being but one normal and customary behavior within this individual's culture. Ultimately, the

individual inculcated this norm through socialization and transmuted it into a personal belief about her world.

Martin also reveals how the cultures within which we are socialized can be "dominant" cultures, or cultures that exhibit values, norms, and standards which take precedence or hold sway over other, perhaps even competing or counter-, cultures and their values, norms, and standards. In her anecdote, she intimates that the culture within which the teacher became socialized possesses features of class, and more specifically, those of the middle-class, for which "being on time" is a normal and customary behavior.

One of the most important features of the model, however, is expressed in the idea that our individual, now an adult, has ascended into a position of authority within an institution: a teacher within a school. And it is in this role as a teacher that the individual, simply in virtue of acting in accordance with her "beliefs, attitudes, and opinions", can uphold and perpetuate the original values, norms, and standards of the culture in which they were socialized. And according to Martin's example, by demanding that her students exhibit punctuality, a teacher socialized within middle-class dominant culture demands acquiescence to and even the reproduction of her middle-class, dominant culture's values, norms, and standards.

In accordance with the Vega model, we can say that the teacher discriminates between certain behaviors, some of which she believes are valuable, others of which she does not. And in her role as a teacher, she exhibits and fortifies the "policies, practices, and standard operating procedures" of an institution that ultimately perpetuates dominant, middle-class values. Martin continues to explain that the discriminating, or

discriminatory, behavior of institutions' representatives can cause harm to individuals, especially to those who may possess characteristics which place them outside of society's dominant culture. She states,

> Not all microcultures (a term currently used by multicultural educators to replace 'minority' to more fully describe the changing demographics in American society) use or value the concept of time and timeliness in the same manner. Children from backgrounds whose concept of time varies from the dominant culture may experience dissonance between the norms of their own cultural group and those of the dominant group. For example, the dissonance may evidence itself in performance of activities that force elementary school students to not only learn multiplication tables but to 'beat the clock.' The point is not whether students learn to be on time, but whose concept of time is perpetuated, whose values are underscored, and to what extent the value systems of microcultural groups are undermined in the process. (p. 54)

Another important feature of the Vega model is the way in which it conceptualizes the "-ism's" we invoke to describe various forms of discrimination. According to the model, for instance, "-ism's" such as ableism, ageism, classism, elitism, heterosexism, racism and sexism are institutional phenomena. Individuals can be racist, but in light of the Vega model's conceptualization of discrimination as being institutional in nature, racists are acting in an institutional capacity and are behaving in ways that disadvantage or disadvantage others within the reach of the particular institution.

Taking the Vega model further, an individual can also be prejudiced but not discriminatory, or even discriminatory but not prejudiced. For example, if an individual has internalized a dominant cultural norm that a certain ethnic group in society is naturally more troublesome than another and utters a disparaging remark to herself about this group while watching television at home alone, we can say that this individual exhibits an individual prejudice, but that her behavior is not necessarily an act of discrimination because she is not in a position to affect others with her beliefs while at home alone. On the other hand, if another individual has not internalized the dominant cultural norm that this particular ethnic group is naturally troublesome and yet has been instructed as a police officer to make more arrests from amongst this ethnic group and, even begrudgingly, complies, we can say that they exhibit discriminatory behavior, but that their behavior is not necessarily prejudicial.

Ultimately, Martin sees Vega's model as an important tool for use in teacher education programs to prepare future generations of teachers to be better able to adapt to evolving classroom demographics. She states, "Prospective educators need a vehicle for comprehending the impact of normative values upon school practices which have the potential to be discriminatory, if they are to act as change agents and transformative intellectuals" (p. 55). She concludes,

> Given the changing nature of public school populations, we can no longer afford to allow teacher education graduates to foster social oppression and inequality. We must continue to search for ways in which to articulate the nature of human

> discriminatory practices and to address the role of the individual in the solution of pervasive issues of human oppression. (p. 56)

Amending the Model

While the Vega model is valuable for illustrating the interrelationships between cultural bias, individual prejudice, and institutional discrimination, it is restricted to analyses centered on these phenomena and thus precludes itself from broader application to sociological and philosophical questions. Here are ways some ways I believe it can be amended for such comprehensive use.

First, the model is explicitly focused on the deleterious facets of dominant culture and how prejudice and discrimination emanate from bias. While in no way suggesting that these facets of dominant culture be overlooked, I contend that the model can be amended to reflect a more general state of affairs that showcases the existence, tout court, of values, norms, and standards; beliefs, attitudes, and opinions; and policies, practices, and standard operating procedures. To reflect this general state of affairs, the model can be altered to depict the social world materially, submerging dominant culture and its transmogrified states into tangible entities within the social world, like artifacts, individuals, and institutions. Second, the model can be changed to more dutifully involve its double-headed arrows, which indicate how each of its components impacts the others at any given time. In its current version, the model functions according to a counterclockwise directionality, beginning with cultural bias and dominant culture and its effect on individuals. Although this can be an informative way to use the Vega model, it foregoes its potential for multidirectionality or analyses of contemporaneous

relationships. And third, and relatedly, the model can be revised to indicate how specific components, like individuals and institutions, can reflexively influence themselves and like others. Figure 2 depicts a version of the Vega model reflecting these considerations:

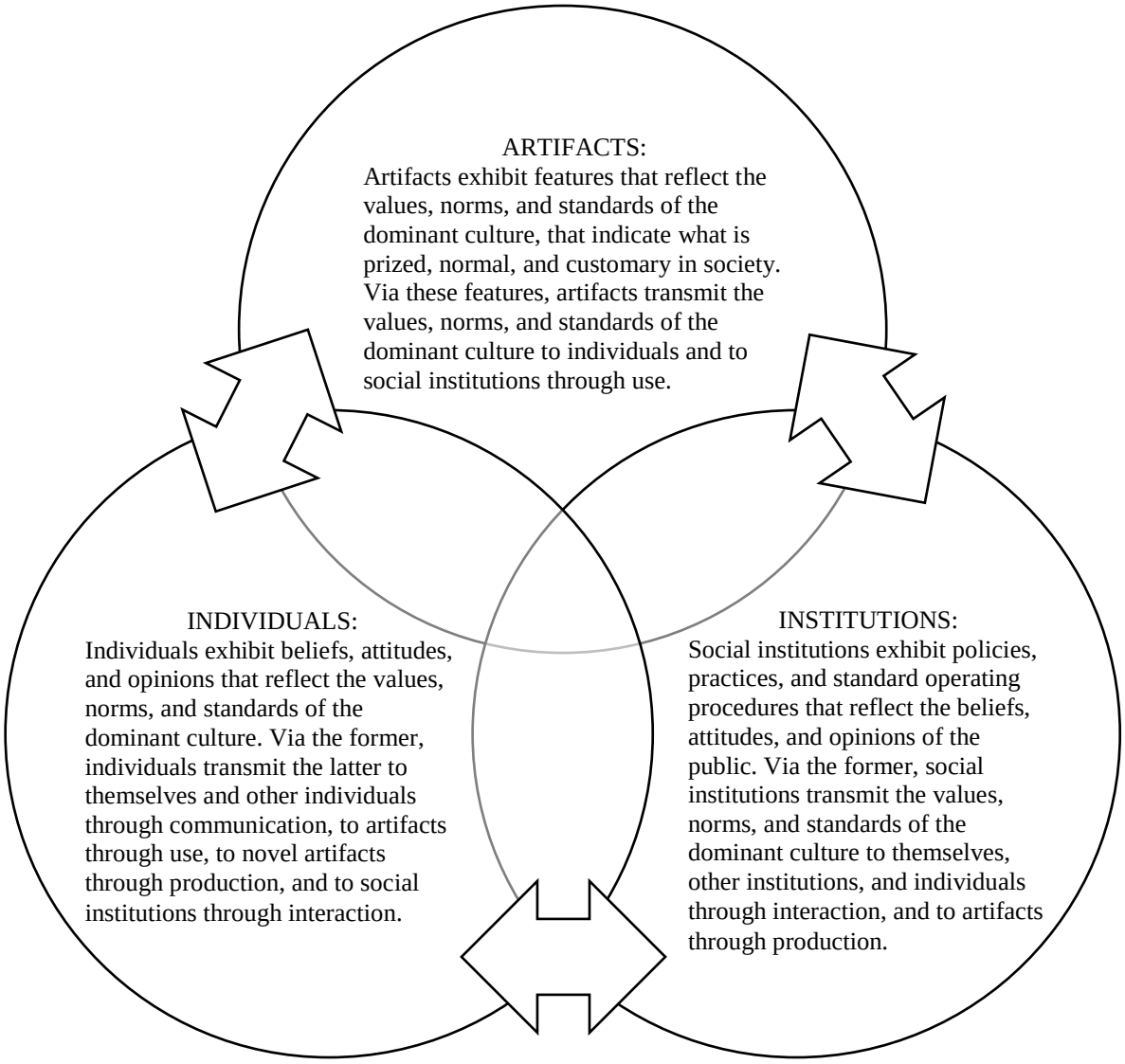

Figure 4 An Amended Version of Flavio Vega's (Martin, 1992) Wholistic Model for the Study of Social Policy on Race, Sex, and Class Diversity in Education

In this version of the Vega model, artifacts, individuals, and institutions replace cultural bias, individual prejudice, and institutional discrimination to not only place focus

on the general states of norms, values, and standards; beliefs, attitudes, and opinions; and policies, practice, and standard operating procedures, but also offer a materialist interpretation of the social world by subsuming dominant culture and its transmuted manifestations into tangible entities that actually come into contact with each other in the world. It also submerges socialization into the model, presuming that it necessarily occurs when individuals come into contact with artifacts, social institutions, and other individuals. Cultural bias, individual prejudice, and institutional discrimination are framed as potential manifestations of these interactions between social entities. Moreover, this version faithfully employs its double-headed arrows by offering descriptions of its components that permit multidirectional and contemporaneous transmissions of dominant culture and its constitutive forms. Finally, the new model indicates that individuals and institutions have the capacity to influence not just overlapping or external phenomena, but also themselves and like others. Indeed, all three entities, artifacts, individuals, and institutions, are assumed and positioned to have the capacity to transmit the norms, values, and standards of dominant culture to each other, except for the possibility of artifacts transmitting dominant culture to each other due to their putative lack of agency.

Applying the Model

Robert Bulman's (2015 [2005]) examination of Hollywood's films about high school employs a methodology strikingly consistent with the Vega model in its elucidation of the ways in which dominant culture relates to class and class identity. It was, in fact, the basis for my reformulation of the Vega model as a heuristic that can

better account for the extent to which dominant culture manifests within and spreads via social artifacts like films.

He begins his analysis by posing a series of questions that get to the heart of determining what constitutes dominant culture: “What is the relationship between film and society? What do films have to teach us about the societies in which they are produced and consumed? Are films primarily a reflection of a society’s culture, or do they in some ways help to shape cultural life independently?” (Bulman, 2015, pp. 2 & 3). He argues that films are complex entities that “reveal a certain truth” (Bulman, 2015, p. 1). The truth they reveal is what a particular society tells itself about itself through narrative and representation. He argues that genre films, “if viewed systematically, tell us truths about the culture that produces and consumes them” (p. 1). In this way, films “are very real and meaningful artifacts of our culture” (p. 1).

But he goes further to trace films’ place within the constellation of production, consumption, and reproduction, and his analysis of this process maps consistently onto the Vega model. Figure 3 shows the Vega model amended to account for the transmission of dominant culture via film, in a manner consistent with Bulman’s analysis:

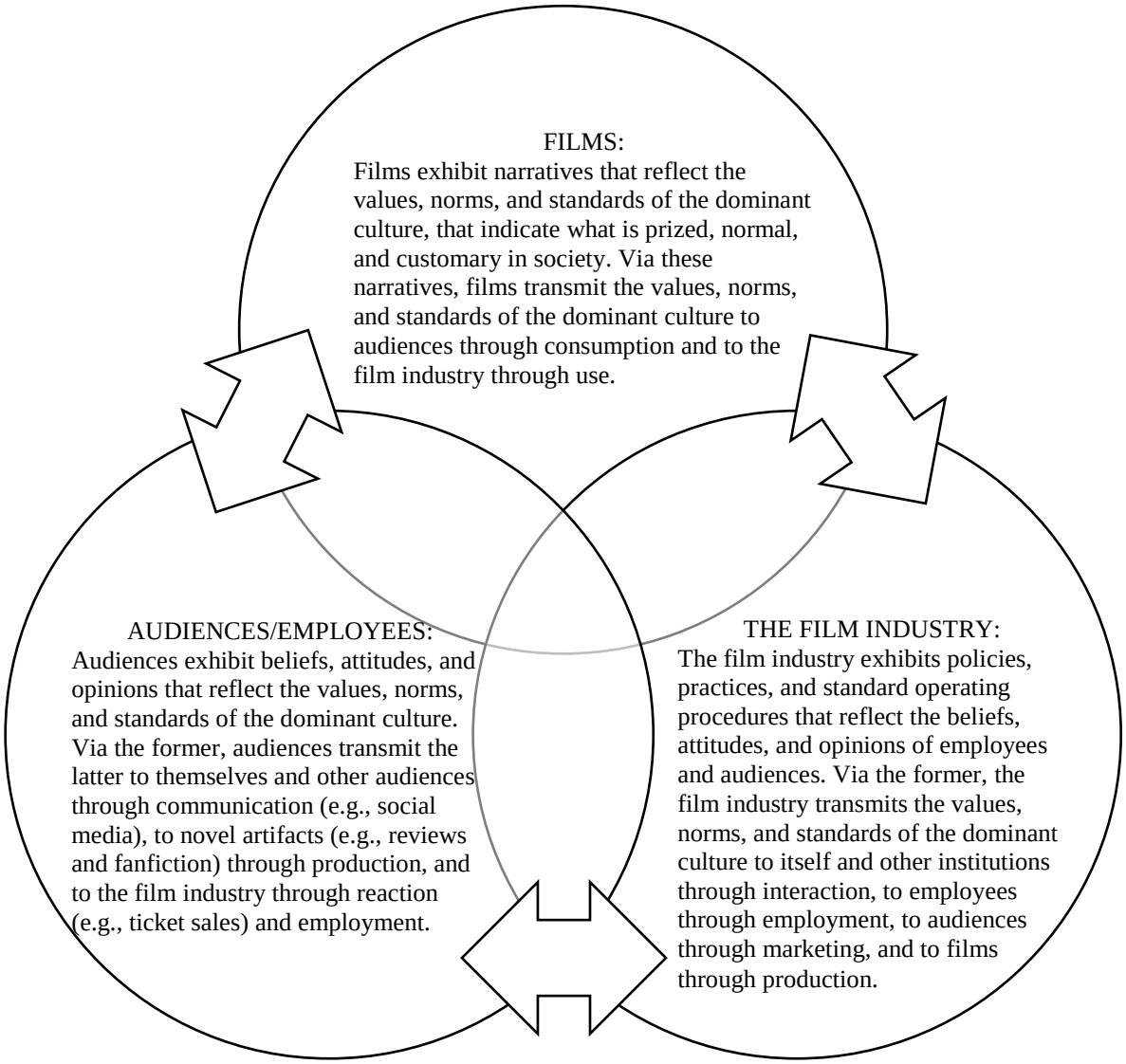

Figure 5 Using an Amended Version of Flavio Vega's (Martin, 1992) Wholistic Model for the Study of Social Policy on Race, Sex, and Class Diversity in Education to Depict the Transmission of Dominant Culture Via Film

According to Bulman, films are the result of a complex of interactions between culture and the public, artists, and the film industry. He explains that the artists who create films have themselves come from the public and its culture. When they create films, they "are attempting to express something about the social world they inhabit" (p. 3). The film

industry exercises its discretion with respect to what kinds films are produced in accordance with what will resonate with the public. And the public's consumption of these artifacts influences industry practices and also serves as a litmus test for the nature of culture itself. He thus explains that "the genre develops in constant interaction among creative artists, commercial interests, and the audience in a 'circuit of culture.'" (p. 3).

And yet, he explains that films are themselves "cultural texts" and can be examined to understand culture as the collection of narratives a public tells itself about itself (p. 3). Moreover, films as cultural texts are not latent; they are pedagogically potent. He writes, "The commercial film industry is a socializing institution. Films *teach* us who we are as much as they reflect who we are. When we go to the movies, we absorb messages about the social world in which we live" (p. 3). Bulman hypothesizes that films' narratives indicate and convey a dominant culture in the United States constitutive of middle-class norms, like "individualism, self-sufficiency, free expression, hard work, and fair play" (p. 4).

Expanding the Model

The Vega model may also be able to be expanded to account for the ways in which multiple social institutions interact with each other and, more specifically, under conditions of authority and subordination. Figure 4 depicts one potential expanded version of the amended Vega model that centers on the interrelationships of the social-institutions discussed in the foregoing theoretical critique:

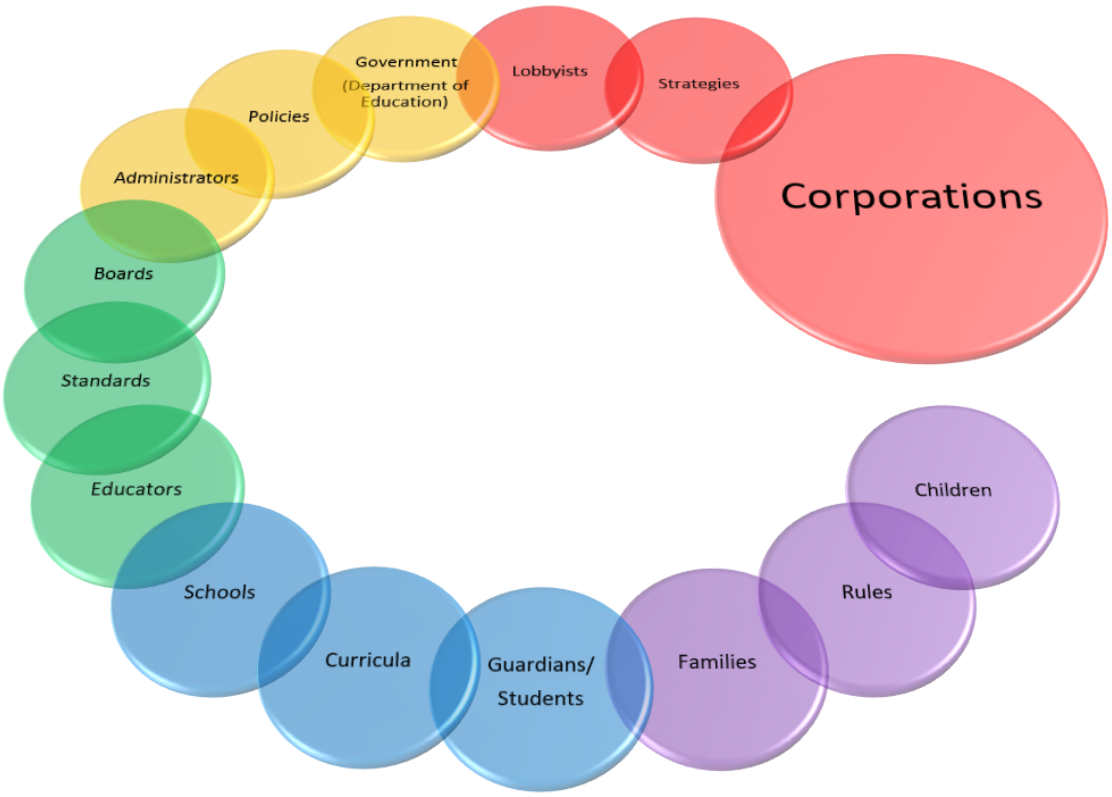

Figure 6 An Expanded Version of Flavio Vega's (Martin, 1992) Wholistic Model for the Study of Social Policy on Race, Sex, and Class Diversity in Education

In this rendering, each monochrome circle triplet represents one Vega model relationship "opened" to the interactions, influence, and cultural exchange of several others within a hierarchical structure. Although the model cannot account for the panoply of ways in which the stipulated entities can and do interact, it is intended to illustrate how the process of dominant cultural reproduction might occur between the entities stipulated in this theorized configuration.

Corporate strategizing thus entails lobbyists interacting with and influencing social institutions like the Federal Government. A corporatized government acts as a powerful social meta-institution that engages in casino capitalism, divests resources from

the social state, and reproduces a competitive dominant culture and neoliberal rationality through its interactions with and influence of subsidiary social institutions like the Department of Education. The Department of Education and its affiliated agencies and interest groups draft policies consistent with the aims of multinational corporations and hold administrators in state and local boards of education accountable to them. Boards of education codify these aims into educational standards and expect educators in schools to abide by them. Schools pursue these standards through curricula and expect guardians and students to comply with them. Families embed an expectation for curricular performance into household rules and expect children to obey and achieve.

Although I will not expound here upon the potential implications of the expanded version of the Vega model, it can still serve as a guide for helping readers to understand the larger context within which the current theoretical critique rests. In accordance with the general implications of this heuristic, therefore, it appears that in society today, a corporate-state controlled process of dominant cultural reproduction renders schools into cites for configuring youth into workers for a social order oriented toward capitalism. This transmogrification of the student into human capital in contrast to a civic being has crucial implications for the state of society writ large, including the extent to which the demos retains its capacity for democratic governance.

References

Bourdieu, P. (1994). Rethinking the state: Genesis and structure of the bureaucratic field. *Sociological Theory*, *12*(1), 1-18.

Bulman, R. C. (2015). *Hollywood goes to high school: Cinema, schools, and American culture*. New York, NY: Worth Publishers.

Martin, R. J. (1992). A model for studying the effects of social policy on education: Gauging the impact of race, sex, and class diversity. *Equity & Excellence*, *25*(2-4), 53-56.

Appendix B. Students' Perceptions of STEM Education

Participant #	*Wave #*	*Grade*	*Gender*
Question: Do you enjoy studying STEM?			
Participants Reporting Enjoyment (1-16)			
Participant 1	Wave 1	7th Grade	Female
Response			
Yeah I actually do.			
Reason(s)			
(A) … we do a lot of experiments … (B) … we don't have textbooks so we don't have to like read. (C) … you need to get ready for life kind of … (D) … so in life everything is not fair so they kind of pushing me.			
Participant 2	Wave 1	8th Grade	Female
Response			
Yeah.			
Reason(s)			
(A) It's what I'm good at. I'm, like, good at math; I'm good at science. (B) I do like reading and that kind of stuff too, but I think that's where I'm going to, like, where I'm going to end up is in a STEM. (C) Even before I came here, I knew that's what I wanted to do.			
Participant 3	Wave 1	8th Grade	Female
Response			
Yeah…			
Reason(s)			
(A) Science Technology Engineering Math is something that's always been interested in … (B) … in my old school we actually had a STEM club that I took part in … (C) it's pretty cool. (D) Math is probably the biggest thing. I've always really... Like enjoyed Math probably one of my favorite subjects if not my favorite subject … (E) It's just really interesting to me … (F) … I planned to be in the medical field just related to Science and Math … (G) … I just feel like it will be a good for me to learn about these things.			
Participant 4	Wave 1	6th Grade	Male
Response			
Yeah …			

Reason(s)			
(A) … I've never really not liked a subject. (B) I've always been a fan of Math and Science. (C) That teacher … really makes the class lot of fun and we still works. (D) … You actually get a whole period about [Algebra I] and that's nice.			
Participant 5	Wave 1	6th Grade	Male
Response			
Yes…			
Reason(s)			
(A) I think it's actually really useful. (B) … I really like math … (C) … in my old school, I really didn't get any math. (D) So the math part is really is useful and all they got here I would say I like all of it.			
Participant 6	Wave 1	7th Grade	Male
Response			
I do.			
Reason(s)			
(A) Um subjects that can challenge you little bit more and … (B) … but are still very important in your life skills and um … (C) I think it's great to focus on those because it's something you really need to have down and you need to understand and I think that's been helpful.			
Participant 7	Wave 2	8th Grade	Male
Response			
Um, I, I enjoy it personally …			
Reason(s)			
I'm mainly interested in the way that, uh, machines work, and… how to make machines do a specific purpose, and… And, the science acs- aspect is using that sort of machine to develop something new. Like, maybe that machine can be developed further to create, uh, maybe a different type of car, like, for instance, hovercraft technology and aircraft technology.			
Participant 8	Wave 2	7th Grade	Female
Response (Offered Prior to Direct Questioning)			
… I was also really excited to go to a STEM school because I really enjoy that stuff …			
Reason(s)			
(A) I'm better at science classes, so I was hoping I would be able to move on with science and kind of stay behind in math, because that's the thing I struggle with, and I'm definitely able to do that here. (B) But like for me, it's like very clear that this is like a lucky opportunity to, like when I found out I got accepted my dad's like 'I did not think you would get accepted, this is a rare opportunity, and you need to take it and run with it.'			
Participant 9	Wave 2	8th Grade	Male
Response (Offered Prior to Direct Questioning)			

But it's definitely a lot more science and technology [at STEM School] because at my old school I would never take physics or forensics, and here I take both of those classes. And I like it a lot, yeah.			
Reason(s)			
(A) Well, I am an athletic person, but I don't really show it. I mainly work with, like, technology because that's like my passion. (B) I've always liked coding and computers. (C) … forensics, I'm taking that and it's very, very interesting. I would love to do that when I get older. (D) … coding is basically a hobby, where that is something I would actually like to get into.			
Participant 10	Wave 2	6th Grade	Female
Response			
Yeah.			
Reason(s)			
(A) That's one of the reasons that I chose to go to [STEM School]. (B) I like how it's sort of links to the other ones. Like, science sort of links to technology. It sort of, it sort of makes you want to inquire more and study the things that you really enjoy. Like people that like art might want to look into arts and music. (C) Well, I sort of feel like STEM shows that you're geeky but most kids enjoy showing that they're a little geeky and that they enjoy, like, technology and innovation.			
Participant 11	Wave 2	8th Grade	Female
Response			
… yeah …			
Reason(s)			
(A) … I really like that this school um has more science and math because um science is my favorite subject and I I'm I love math … (B) I mean like we still focus on English and social studies but that's kind of I mean it's still important but it's kind of lower than the science and the math is what's really important. (C) I actually I want to go in to science I want to be a physicist so um it's nice that I am really getting the opportunity to focus on math and science more so I I just really like that it's more of that and less of like it's really just what you I don't know um like it's it's just more science and math and that's nice.			
Participant 12	Wave 2	6th Grade	Male
Response			
… I do enjoy studying STEM …			
Reason(s)			
(A) I really like, uh, all of those topics. I like science and math the most, and I also like technology and engineering. They're all interests of mine. (B) I want to...study chemistry [in college].			
Participant 13	Wave 2	8th Grade	Female
Response (to "… how do you feel about studying STEM?")			

… I find it very beneficial …			
Reason(s)			
(A) … because I will use it later on in life. (B) 'cause I will…um, science is related is related to everything and so is math. (C) Technology and engineering is in…like, the future, so then…in other words this helps you be prepared for what's going to happen…and, like, it's already evolving over time towards technology and engineering, which will be very good to learn about it. … Um yeah, [peers] really [like studying STEM], because they find that it's going to be very um, good in the future. They have, like, the same beliefs as I do…because they believe that this school will help you later on in life. That this will help you increase and become advanced in everything … (E) … so that it'll help you get the job you want … (F) … and help you become what you wanna be.			
Participant 14	Wave 2	7th Grade	Female
Response			
Yeah.			
Reason(s)			
(A) … I really like math and science, I really like both of those. (B) I'm not a big fan of language arts, so it's kind of good - they don't really focus on it. (C) I guess technology is fun. (D) But so now they kind of focus on the things I really like, I just like it.			
Participant 15	Wave 2	6th Grade	Female
Response			
Yes.			
Reason(s)			
(A) Uh, so, Science, Technology, Engineering, and Math … Those are my favorite subjects, out of anything. If I could just not take a literature subject and take another science course, I would definitely do that. (B) … they also say literature is my best subject, but it's definitely not my favorite. (C) We have forensics and that's really fun.			
Participant 16	Wave 2	6th Grade	Female
Response ((A) Offered Prior to Direct Questioning; (B) Offered After Direct Questioning)			
(A) … I help some of my friends with math … (B) I like science and I like technology …			
Reason(s)			
(A) … mostly because I'm really good at math. (B) Science being able to learn about like different parts of the body and stuff and insides and stuff because it's medical to me … (C) … and technology I really like about technology is being able to see inside the computers how to program stuff all that. (D) … I just like being able to solve the different equations and knowing that like oh I solved this equation and like really hard equations that like I didn't know I could be able			

to solve and stuff and being able to go really solve equations like and stuff like that really fast just lets me know like oh I'm really good at this I'm actually good at something.			
Participants Reporting Ambivalence (17-21)			
Participant 17	Wave 1	8th Grade	Female
Response			
It's okay.			
Reason(s)			
(A) I wanna be like a counsellor. (B) I mean right now. I was I will just stick to STEM.			
Participant 18	Wave 1	7th Grade	Female
Response			
Um . . . math, kind of. But I mean, science . . . I really like it …			
Reason(s)			
(A) I'm just really bad at [science]. (B) I didn't choose [STEM School]. (C) I was forced to come here.			
Participant 19	Wave 1	6th Grade	Female
Response			
I do enjoy studying... like some of the things that we are doing …			
Reason(s)			
(A) I don't really understand much about the STEM program. (B) I am just concentrating on trying to get my grades up right now.			
Participant 20	Wave 2	8th Grade	Male
Response			
I think it's alright.			
Reason(s)			
(A) Um it's not really um like my favorite subject … (B) I have no problem 'cause every school has science and uh math and they um -- involve technology with it like they use like in science they use labs with whatever like technology in the labs.			
Participant 21	Wave 2	6th Grade	Female
Response			
I think it's okay.			
Reason(s)			
(A) It's a good curriculum because, um... it's just kind of more standardized, so you can have what you need. (B) But, um... the grade work still definitely needs work.			
Participants Reporting Lack of Enjoyment (Dislike) (22)			
Participant 22	Wave 2	7th Grade	Female
Response			
Uhm, I, kind of. I don't like, I don't like math or engineering. But, I like certain, I like more natural science, like biology kind of stuff.			
Reason(s)			

(A) But, I'm more of an English and arts type of person than math and science.
(B) It's just that the, it's just that the coursework won't always be super interesting, the science and whatever.
(C) And they, I guess, they were hard. Because I had math, which I never like, and then physics [and] transportation was my science class, which physics is basically a second math class. So, I did not, I didn't really, I didn't like that class.
(D) Yeah, and I [had] to do them, because it's math and I [...]