A Mapping of Historical Discourses in STEM Advocacy Literature

by

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ABSTRACT

Efforts to privilege STEM (Science, Technology, Engineering, and Mathematics) disciplines, initiatives, and industries in American discourse are arguably the foremost expressions of scientific authority in contemporary educational policy. Citing a diverse body of STEM literature, I discuss the histories and rationales that sustain the promotion of STEM. In doing so, I appropriate two concepts -Michel Foucault's Regime of Truth and Hayden White's Emplotment- for the purpose of analyzing the complex interests embodied by STEM discourse. I argue that the Sputnik Narrative is the prevailing story in STEM advocacy discourse. I claim that STEM advocates typically emplot this history as a Romance. Furthermore, I classify two major bases of appeal (rationales) that appear within this literature to justify STEM projects and proposals, "competition" and "equity." Throughout my writing, I cite discursive strategies for challenging and reimagining STEM history. My goal in indicating these sites of narrative possibilities is broaden the discursive field to new, perhaps liberating possibilities.

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CHAPTER 1

INTRODUCTION

During the decade or so since the nouns Science, Technology, Engineering & Mathematics entered American discourse as a particular configuration of letters - "STEM"- the term has been regularly cast as an ongoing concern for education and the future of U.S. political, economic, and social relations. As encountered in so many speeches, proposals, annual reports, requests for proposals, reform plans, mission statements, and term agendas, the prescriptions appearing in STEM discourses appeal to the regulatory conventions of historical and scientific truth in their advancement of a particular, strategic telling of American history and its relationship to STEM. In particular, I identify *Sputnik* as a rhetorical trope within STEM discourses and consider coincidence with two, sometimes discordant, ideological objectives: (a) national competitiveness and (b) social equity. The proceeding text provides an account of this truth-telling strategy, its narrative limitations, and possible strategies for eluding these narrative constraints. My interest is to develop a more liberating field of narratival possibilities with respect to STEM discourse so that when reformist educators are enjoined to speak, we might be free to explain ourselves and our projects on our own terms.

The initial sliver of inspiration for this study began several years ago when my attempts at finding work appropriate for an educator with reformist aspirations yielded several offers from programs promoting a STEM agenda. Interested, I began investigating STEM as a way of understanding its relationship to my goals and, after becoming employed, to justify my work. I found it easy to locate sources arguing for

STEM as a vehicle of social mobility (which, in the spirit of "full disclosure," I do admit favoring); however, I also encountered more nationalistic arguments, representing STEM as a means of dominating global economies and territories. How could both discourses be true? In siding with STEM, whose side was I on?

Notwithstanding my personal dilemma, there are other reasons readers might take interest a study of this kind: first, debates over STEM initiatives make frequent use of scientific language and metaphors, which –although illustrative of ideological authority- do not necessarily assure the desirability of their outcomes. For example, as political discourse is reduced to the specialized language of scientists, questions might be raised concerning public access to the political processes and the development of a technocracy (e.g. environmental policy). Second, STEM provides an opportunity to reflect the means by which "the past" is cultivated and selectively endorsed to support specific, political and ideological aims (i.e. historiography). Third, I am interested in exploring the tensions and contradictions that occur when such a diverse coalition (i.e. STEM promoters) appropriate the same trope (i.e. Sputnik), but for differing reasons (i.e. economy, military, and/or equity) because I believe scrutinizing these sites of coalitionary friction can yield insights into the tactics and relative power of participating agencies. Finally, in my conclusion I discuss some epistemological approaches theorists have developed in response to what I call *the problem of liberation*: how to engage in meaningful politics when narratives are contingent, strategies are suspect, and consent is not necessarily equal to freedom. Before developing my concerns regarding the redistribution of meanings in STEM discourse, I begin with a discussion the meanings of some terms and their functions within STEM discourse.

Defining STEM

"The best lack all conviction, while the worst / Are full of passionate intensity" W.B. Yeats (1919/1988).

Although STEM denotes an eminently knowable term that is comprised of discrete components (Science, Technology, Engineering, and Mathematics), this sense of comprehensibility dissolves upon examining these components and their connotation. Consider, for example, the following list of "determinations," which constitute the Government Accountability Office's (GAO) definition of STEM fields:

> We determined that a STEM field *should be* considered any of the following broad disciplines: agricultural sciences; biological sciences; chemistry; computer science; earth, atmospheric, and ocean sciences; engineering; mathematics; physics; social sciences (e.g., psychology, sociology, anthropology, cognitive science, economics, behavioral sciences); or technology. In addition, we determined that our definition of STEM education would include health care programs that train students for careers that are primarily in scientific research. We did *not, however*, include health care programs that train students for careers that are primarily in patient care, that is, those that trained nurses, doctors, dentists, psychologists, or veterinarians. (United States & Scott, 2012, p. 36; emphasis mine)

The principles governing these determinations are undefined within the text; however, one anticipates that inclusion of biological sciences, but exclusion of nurses, doctors, dentists, psychologists, and veterinarians can only be explained as an expression of esoteric political compromise. Even more confounding, many educational initiatives to which the STEM acronym has been applied are not necessarily identified with a specific academic institution or discipline. These "STEM education programs" are defined in similarly opaque terms in the same GAO report cited above (United States & Scott, 2012); STEM Education programs include any or all of the following objectives:

> (1) attracting or preparing students to pursue classes, coursework, degrees, and/or work in STEM areas,
> (2) providing training opportunities for undergraduate or graduate students in STEM fields (e.g. grants, fellowships, internships, and traineeships),
> (3) improving teacher (pre-service or in-service) education in STEM areas,
> (4) improving or expanding the capacity of K-12 schools or postsecondary institutions to promote or foster education in STEM fields, or
> (5) conducting research to enhance the quality of STEM education programs provided to students. STEM education programs may, therefore, assume the character of multiple formal or informal education activities (e.g. classroom instruction, contests, science fairs, and summer programs.) (pp.34-35)

Obviously, there are also many programs that could be argued to pursue these objectives without express or recognized affiliation with STEM (e.g. anything to do with medical professionals).

The meanings of STEM are further complicated by the practice of subtracting or adding letters to the acronym. Speaking in February, 2012, before an audience of educators and lobbyists, the CEO of Change the Equation, Linda Rosen, illustrates this with good humor:

> STEM's a great word; it's the best acronym we've had in my career, that's for sure; you would say from [the standpoint of incorporating] other fields, it's especially good -you can put an 'A' in [arts: "STEAM"], you can put an 'R' in [robotics: "STREAM"], and you still have a word; I know some folks want to put an 'H' in [health sciences: "STEM+H"]. I don't know how to pronounce that word. (as quoted in ChangeTheEquation, 2012)

The cases of STEAM, STREAM, and STEM+H are only a few examples of supplemental "STEM" configurations. For example, at least one author has recommended removing the "S" to spell "TEM," because some economic data indicates that "Science PhDs" are less paid and are less employable than professionals representing other "STEM" disciplines (Weissmann, 2013). "iSTEM," meanwhile, stands for "integrative STEM" and is apparently intended to emphasize curricular connections between STEM disciplines

(Sanders, 2009).[1] What is more, each letter does not always necessarily represent the same word: R can mean "Robotics" or "wRiting," for example (Root-Bernstein & Root-Bernstein, 2011).

In summary, what we are dealing with is an ideograph, "a high-order abstraction representing collective commitment to a particular but equivocal and ill-defined normative goal" (McGee, 1980, p. 15). As it stands, STEM is too politically useful to be bound by a more elegant or principled definition. Greater terminological rigor might jeopardize the power of STEM to channel the interests of its diverse constituencies under one banner. Instead, the political clout and resources of STEM are effectively put up for grabs to any entity capable of sufficient assertive force to declare, "I know it when I see it." What follows is an illustration of historical possibilities that are obscured by the dominant STEM narrative, cardinal functions within this narrative, and the benefits that correspond with its appropriation.

STEM History: Obscured Possibilities

If it is not possible to define STEM in a more principled way than by simply listing determinations, then another approach might be to cite tradition and argue for a historically authentic definition. The difficulty with this strategy is that several candidates that might be chosen for similar reasons. For example antecedent terms like SL (Science Literacy), S&T (Science and Technology), or S&E (Science and Engineering), also represent entire disciplines and professions a combination of letters and share many

[1] Until the ascendancy of STEM, Mark Sanders, an advocate of iSTEM, had previously published works promoting a similar agenda that predates the STEM acronym, called "TSM Connections" [Technology, Science and Mathematics Connections] (laPorte & Sanders, 1995; Sanders & Binderup, 2000).

overlapping interests with STEM. Indeed, one could argue that the only distinction between STEM and these other terms is an apparent advancement in aesthetics and marketability.

For example, Science Literacy is also subject to (1) terminologically unrigorous usage, (2) features historical narratives tracing their origins to the late 1950s, and (3) shares overlapping discursive preoccupations. For instance, the “Some STEM for All” verses “All STEM for Some” distinction advocated by the Information Technology and Innovation Foundation (Atkinson et al, 2010), corresponds rather easily with what SL historian, Douglas Roberts (2007), has identified as competing goals: “Vision I” (i.e. specialist) vs. “Vision II” (i.e. populist) in SL discourse. But half-redundant concepts and agendas that comprising educational discourse would offer many such routes to the teleological triumph of our arbitrary darling, STEM. Its mutant siblings and disfigured doppelgangers that “came before,” or “developed beside” are too many to document. Seeking a more concrete approach, I resort to tracing the term’s coinage.

STEM emerged as a distinctive term in 21st Century American discourse sometime during 2001, when Judith Ramaley, then director of the National Science Foundation (NSF), rebranded a slightly older acronym, SMET, with the apparent intention of avoiding certain lyrical affinities with the word "smut" (Sanders, 2008). Since then, the new arrangement of letters has enjoyed a much wider distribution than its predecessor; indeed, by December of 2003, *The Journal of SMET Education* had already changed its name and website domain to reflect the new brand.[2] At the time of this

[2] Given the apparent motivation for rebranding SMET, it is especially amusing to read an apology prefacing the transitional issue from JSMET to JSTEM, in which the editors regret prematurely dispensing with their old url (jsmet.org), "not realizing that it would be immediately picked up by a Rumania-based

writing, a quick search of “science, technology, engineering, and mathematics” on Google Scholar has yielded 20,000 links, 15,500 of which were produced since 2003.[3]

So, if STEM came from SMET, where did SMET come from? There is a danger of infinite historical regress here, so perhaps it would be better to impose some dimensions on the subject or else risk becoming discouraged.[4] Historical precedents for distinguishing STEM from other disciplines may be considerably older than the 20th Century. For example, analogous categories might be perceived in the *Quadrivium*/*Trivium* distinctions that were popularized during the Renaissance era and which recognized arithmetic, geometry, music, and astronomy under the former disciplinary grouping, while organizing grammar, logic, and rhetoric under the latter.

Otherwise, the rationales for such a STEM/other distinction may also be linked to Platonic mimesis, for example, whereby "ideal forms" (e.g. numerical abstractions, like "6") are privileged over physical "substances" (e.g. a particular chair) because the former is believed to embody a kind of immutable, truer, and diviner reality. Further historical candidates might be cited (e.g. the *epistêmê*/*technê* distinction of antiquity, or its modern analogue theory/practice), but, once again, the project of naming ancestors depends on a combination of loose analogies, arbitrary definitions and a resolute indifference to complaints of “anachronism.” In registering their own conservative assessment (limited to an American purview), GAO authors similarly, observe, “depending on how broadly the term is defined, federal interest in STEM education may be traced to the 1st

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pornographic site. [...] We wish to apologize for any embarrassment this may have caused to those of you inadvertently visiting the old address” (Raju and Chetan 2003, p. 2).

[3] Simply searching “STEM” returns too many unrelated results to be considered illustrative (e.g. “stem cells”).

[4] For example, Donahoe (2013) has surrendered the effort, concluding: “The origins of the acronym SMET seem lost to history” (para. 3).

Congress" (Gonzales et al., 2012, p. 30).[5] Suffice it to say, that the arrangement of curricular politics and initiatives presently called "STEM" could be construed as having developed from any number of historical antecedents that are as ancient as the Ancients or as modern as Modernity.

But, in practical terms, perhaps it is better to consider the story one does encounter, rather than the possibilities one might, or might prefer to, encounter. What is the narrative that has so successfully sustained interests as varied and expansive as those presently championing STEM? The story begins on October 4, 1957.

Sputnik Narrative

Sputnik, the 180 pound satellite that broadcast its chirping radio signal around the planet for about 22 days, is the key figure in most accounts of STEM and its origins (Garrett, 2008; Chikoore, 2008). Even within American history, this is an arbitrary choice. There are other plausible alternatives. Stuyvesant High, the so-called "first STEM high school," was founded half a century earlier, in 1904 (Thomas & Williams, 2009).[6] West Point, which was founded in 1802, is frequently remembered as "the first, and one of the foremost, schools of professional engineering in the nation" (Weigley, 1962, p. 27).[7] Likewise, the Morrill Act of 1862, which stipulates each state must sponsor at least one college "to teach such branches of learning as are related to agriculture and the

[5] The authors cite a statement attributed to George Washington, which celebrates "the promotion of science and literature," as knowledge: a political good and "the surest basis of public happiness" (Gonzales et al., 2012, p. 1).

[6] Many of these early-20th Century high schools to which the term 'STEM' has been, or might be, applied (e.g. Brooklyn Technical High School, Bronx High School, etc.) were established "not to enhance the skills or provide opportunity for the gifted and talented, but rather to prepare a workforce with specific technical skills" (Thomas & Williams, 2009, p. 18). This mundane concern for vocational training poses a mild contrast against the anxious, quasi-existential concerns often cited in contemporary STEM narratives.

[7] Also see also Judson (1904, p. 835).

mechanic arts,” could also function as a viable symbol of national interest in what might be called "STEM" knowledge (2 July I862)

To characterize the choice of Sputnik as arbitrary is only correct in a technical sense. From the standpoint of rhetorical emphasis, however, beginning with Sputnik serves very specific purposes. Sputnik poses unique advantages that can explain its popularity, particularly among educationalists and others whose participation in STEM discourse depends on grants, endowments, and the appeal of a strong, indeed, crisis-evoking “need-statement.” This will be discussed in further detail elsewhere in my analysis. For now, I continue with a description of what constitutes the typical STEM narrative.

The National Defense Education Act

STEM Narratives typically cite passage of the National Defense Education Act (NDEA) in 1958 as the origin of modern STEM-specialized education in the United States. The NDEA represents a landmark in federal education funding. At a distributed budget of $1.4 billion over 4 years, the act authorized unprecedented federal expenditures in the form of loans, scholarships, and graduate fellowships with the express purpose of ensuring that "no student of ability will be denied an opportunity for higher education because of financial need" (Title I, Sec. 101). Importantly for STEM, however, the NDEA also stipulates that funds be especially devoted to "students whose academic background indicates a superior capacity or preparation in science, mathematics, engineering, or a modern foreign language" (Title II, Sec. 204). In this respect, the NDEA

is like many of the prospective STEM ancestors I have outlined: a symbol of strengthened ties between the federal government and educational institutions.

Since 1958, the legacy of the NDEA in STEM discourses has been strategically cast according to their proportional emphases on economic competition, military dominance, and social equity within a Sputnik narrative. In Chapter 2, I describe theoretical insights that are relevant to historiography and offer insights into the rules governing historical narratives.

CHAPTER 2

HISTORIOGRAPHICAL THEORY

Theoretical insights for this paper draw on the works of Michel Foucault and Hayden White. These works raise questions concerning the accessibility of *the past as it actually happened*, the procedures that govern historiography, and the operation of power within these existentially affirming truths. Both theorists characterize truth as an effect derived from social constructs. White (1973), for example, attributes the scientific truths in physics to language -"terminological discipline"- which allows it "to provide an adequate schema of words for representing the schema of thoughts which it takes to be the truth about reality" (p. 33).

Although similar in this respect, Foucault and White are not necessarily complimentary theorists. For example, White (1978) distances himself from Foucault's work when he characterizes it as "absurdist" and "anticivilizational" Indeed, White seems to renounce poststructural philosophy in general when citing Lucien Goldmann, Roland Barthes, Michel Foucault, and Jacques Derrida and stressing "that I regard the latter […] captives of tropological strategies of interpretation." (p. 3). White specifically criticizes Foucault on grounds that he "does not seem to be aware that the categories he uses for analyzing the history of human sciences are little more than formalizations of tropes" (p. 3).

Even in leveling these criticisms, however, White (1978) also delivers among the most compelling ethical arguments for this so-called anticivilizational thought: "reversing the hitherto unquestioned assumption that 'civilization' is worth the price paid in human suffering, anxiety, and pain by the 'uncivilized' of the world (primitive peoples,

traditional cultures, women, children, the outcasts or pariahs of world history) and asserting the rights of the 'uncivilized' against the 'civilizers,'" (p. 269). In other words, the uncivilized thought of absurdist critics is concerned with the ways in which "social products […] are not only complicit in the violence that sustains a given form of society, they even have their own dark underside and origin in criminality, barbarism, and will-to-destruction" (p. 269). The outcome of this project, according to White, amounts to a kind of retreat into nihilism, however; it means resignation to a condition endless metaphorical translation. I return to this issue during my conclusion where I hope develop a response to the problem of liberation.

In any case, the proceeding descriptions and application of Foucault's *Truth Regime* and White's *Emplotment* should not be read as authentic or faithful to each theorists' intentions, but rather judged according to the criteria that White (1973) recommends for historical literature: "consistency, coherence, and illuminative power" (p. 4).[8] In this respect, my constant aim with this project is to dissolve the centered truths that would consolidate STEM as a site of power within American politics. That is, to open the discursive field to movement and possibilities.

Michel Foucault and Truth as a Regime

"There is a crack in everything / that's how the light gets in." – Leonard Cohen (1992)

[8] Given both theorists' conceptualization of history in relationship to politics, ideology and power, it seems likely they would anticipate and oblige the repurposing of their work. Foucault is explicit on this subject: "All my books are little tool-boxes. If people want to open them, to use this sentence or that idea such as a screwdriver or spanner to short-circuit, discredit system of power, including eventually those from which my books have emerged… so much better. (Foucault et al., 1979, p. 115)

Critiquing the historical narratives that function within, and comprise, STEM discourse requires an examination of relationships between the agencies and powers that generate truth in our society. The operative question may be phrased in aesthetical terms. How is the *effect* of truth produced? What literary conventions can sustain a suspension of disbelief and allow audiences to distinguish historical truth from falsehood? Michel Foucault (1980) provides a name for the entity, or rather "regime," in question:

> Each society has its regime of truth, its 'general politics' of truth: that is, the types of discourse which it accepts and makes function as true; the mechanisms and instances which enable one to distinguish true and false statements, the means by which each is sanctioned; the techniques and procedures accorded value in the acquisition of truth; the status of those who are charged with saying what counts as true. (p. 131)

Foucault (1980) describes a regime of truth as pervasive, intimate and diffuse in its operation. Characterized as an "ongoing subjugation," it functions "at the level of those continuous and uninterrupted processes which subjugate our bodies, govern our gestures, dictate our behaviors, etc." (p. 97). "Historically contingent," its form draws upon pre-existing discourses that function simultaneously as both a product and means of authority (p. 101). The most enduring instances of discursive power may appear to transcend history or may not appear at all (Low & Lawrence-Zúñiga, 2003), but is better understood as an imperfect assertion of power. However, even these enduring truths can be shown to be imperfect and mutable. Meaning "is never absolutely determinable [...] its determination can never be entirely certain or saturated" (Derrida, 1988, p. 3). There can be no final victory of truth over the renewal of possibilities.

In this respect, notions of dominant verses non-dominant oppositions oversimplify what is ultimately a limited relationship between given discursive powers (Foucault,

1990).[9] The relative authority of a given truth is dynamic, as “power only exists in action” (Foucault, 1980, p. 89). These actions operate through “a system of ordered procedures for the production, regulation, circulation, and operation of statements” (Foucault, 1980, p. 133).

According to Foucault (1980), the truths of modern Western societies are expressed in the language of science; a true story, argument, or discovery can hardly be imagined without reference to empiricist metaphors and conventions. Foucault describes a truth regime comprised of five parts:

> In societies like ours, the ‘political economy’ of truth is characterized by five important traits. [1] ‘Truth’ is centered on the form of scientific discourse and the institutions which produce it; [2] it is subject to constant economic and political incitement (for demand for truth, as much for economic production as for political power); [3] it is the object, under diverse forms, of immense diffusion and consumption (circulating throughout apparatuses of education and information whose extent is relatively broad in the social body, notwithstanding certain strict limitations); [4] it is produced and transmitted under the control, dominant if not exclusive, of a few great political and economic apparatuses (university, army, writing, media); lastly, [5] it is the issue of a whole political debate and social confrontation (‘ideological’ struggles). (1980, p. 131)

This means that even under circumstances in which the avowed preconditions of scientific investigation cannot be met (e.g., repeatability, isolation of variables), the tropes and figures of empiricism are espoused throughout authoritative institutions as a conventional cue indicating the incidence of a true discourse. Rather, "Science is still the legitimating icon that serves as both synecdoche and metonymy for all that is rational and good in western society, if not for western society itself" (Croissant, 2000, p. 225). The resulting discourse might be dismissed as merely a “scientistic” performance; however,

[9] Claims concerning rupture or continuity come down to the methodological question, "how to measure historical change?" Here, the situation is rather like, as Vladimir Nabokov describes in one of his novels: "that old sophism of changed handle and changed blade” (1959, p. 82). Foucault’s contribution has been as an exceptional voice arguing for the validity of discontinuity as a historical thesis.

such a criticism presumes a non-arbitrary, authentic empiricism against which to compare inauthentic empiricism (i.e. reification of the truth regime).

STEM advocacy discourses are unique in their relationship to the western Truth Regime. A kind of authentic evangelization, STEM discourses are not only complicit with the regime in their use of empirical metaphors, but also deploy these metaphors in explicit service to the regime. It not only serves the regime, but embodies it.

Hayden White and The Emplotment of Historical Truths:

"You see, I think we ought to be precise about facts -I mean, very, very precise about historical facts. Or I mean, for God's sake, let's try to be. Or I mean for God's sake, let's pretend to be. Or something!" – WallaceShawn (1997)

In the field of historical theory, questions concerning the adequacy of narrative and its ability to convey a "true past" through empirically valid methods has been a source of contention since the so-called "Enlightenment Project" began (Harvey, 2011).[10] "Historical truth" is generally believed to exist in any narrative that describes past events with some degree of correspondence to a shared reality. There is no formal criterion in historical studies for judging correspondences between the text and reality (Novick, 1988). Approaches attempting to mimic the formidability of the scientific method are inadequate for reasons described by Hayden White (1990):

> To many of those who would transform historical studies into a science, the continued use by historians of a narrative mode of representation is an index of a failure at once methodological and theoretical. A discipline that produces narrative accounts of a subject matter as an end in itself seems methodologically

[10] Consider, for example, the enlightenment-era historian of The Royal Society, Thomas Sprat, whose work advances an nationalistic opposition between words and things: "as they [the French Academy] undertook the advancement of the elegance of speech, so it became their history, to have some resemblance to their enterprise: whereas the intention of ours, being not the artifice of word, but a bare knowledge of things" (Sprat, 1667/1958, p. 40). Here, the "word" is equated with artifice and "things" function as the site of true, bare knowledge.

> unsound; one that investigates its data in the interest of telling a story about them appears theoretically deficient. (p. 26)

In other words, history is a discipline that creates, by discursive means, the object that would serve as the referent of inquiry. This autopoetic quality distinguishes history from typical understandings of science insofar as empirical inquiry presupposes a referent that exists independently from the works of professional historians. Alternatively, White (1973) characterizes historical truth in aesthetic terms as having more to do with performing within the bounds of decorum than with the revelation of certainties in correspondence with a transcendent truth. He instead argues that the validity of a historical argument depends on "the consistency, coherence, and illuminative power of [the historian's] respective visions of the historical field" (p. 4). In other words, the truths of history are literary.

What is the value of a history that limits its accountability to questions of realism, but never reality? White (1973) argues that recognizing the formal and aesthetic register of a historical narrative provides insight into the assumptions and motives of speakers and the discourses they embody:

> It is imperative, therefore, when analyzing putative 'realistic' representations of reality to determine the dominant poetic mode in which discourse is cast. By identifying the dominant mode (or modes) of discourse, one penetrates to that level of consciousness on which a world of consciousness is constituted prior to being analyzed. (White, 1973. p. 33)[11]

The claim, here, is that historical narratives are prefigured by the author/discourse, not through a process of overdetermined evidence gathering, but through literary choices that

[11] Although often described as a radical theorist, White's thought also supports a conservative vision of interpretive determinism when, for example, conceptualizing of the chronicle as "unprocessed historical record." The position is untennable, considering that any utterance circulates knowledge-power and therefore cannot be represented in an ideologically innocent, unprocessed form (White, 1973).

are decided with indifference respecting the historical subject or evidence. For example, according to White, there are four, *a priori* modes of emplotment from which historians may mix and match narrative strategies: Romance, Satire, Comedy, and Tragedy and raises the possibility of the Epic as a fifth (pp. 8-9). Directly corresponding with traditional literary forms, these emplotments (i.e. narrative modes) illustrate the pre-existing heuristics, constraints, and conventions that shape historical narratives and truths. For the sake of space, I will only reproduce his definition of the Romance, since it is the mode of emplotment that features most prominently in STEM narratives: The Romance is “fundamentally a drama of self-identification symbolised by the hero’s transcendence of the world of experience, his victory over it, and his final liberation from it [...] It is a drama of the triumph of good over evil, of virtue over vice, of light over darkness, and of the ultimate transcendence of man over the world in which he was imprisoned by the Fall" (p. 8).

White (1973) argues that reading historical texts by identifying their "particular combination of modes of emplotment, argument, and ideological implication" allows insight into "the poetic act" of the historian, which precedes any formal analysis of the field. This is not a restatement of what New Critics have rightly spurned as “the intentional fallacy” (Wimsatt & Beardsley, 1989). Rather, White’s conceptualization of historiography as a poetic act emphasizes the formativity of preexisting discourses and conventions. In other words, the relative agency of the historian is complicated so that when White writes that the historian “both creates his object of analysis and predetermines the modality of the conceptual strategies he will use to explain it," the statement also applies to historical discourses (p. 31).

White's approach promises access a transformed discourse that is not created by an authorial actor, but translated through a discursive subject. This model presents the possibility claims with broader social relevance than would be possible through a propurted (purported?) reconstruction of an authorial subjectivity. In a more detailed passage, White (1973) describes the process:

> ...before a given domain can be interpreted, it must first be construed as a ground inhabited by discernable figures. The figures must be classifiable as distinctive orders, classes, genera, and species of phenomena. Moreover, they must be conceived to bear certain kinds of relationships to one another, the transformations of which will constitute the 'problems' to be solved by the 'explanations' provided on these levels of emplotment and argument in narrative. (p. 30)

This ordering of discernable figures in accordance with conventional relationships not only influences the outcome of historical truth, but does so without necessary reference to the evidence under examination. Here discursive power, in the form of convention, accounts not only for the historical process, but also the product:

> …the very claim to have distinguished a past from a present world of social thought and praxis, and to have determined the formal coherence of that past world, implies a conception of the form of knowledge of the present world also must take, insofar as it is continuous with that past world. Commitment to a particular form of knowledge predetermines the kinds of generalizations one can make about the present world, the kinds of knowledge one can have in it, and hence the kinds of projects one can legitimately conceive for changing that present or for maintaining it in its present form indefinitely. (White, 1973, p. 21)

This conservative act of creation shapes both the possibilities and constraints posed by the historical circumstance it describes. In illustration, White uses the controversial work of Andreas Hillgruber, *Zweierlei Untergang* (Two Kinds of Ruin), as a text in which the expert historian's "choice of a mode of emplotment can justify ignoring certain kinds of events, agents, actions, agencies, and patients that may inhabit a given historical scene or its context" (2001, p. 379). Hillgruber's division of Nazi history into two narrative

emplotments, (1) a tragedy describing, on one hand, “the shattering of the German Empire” and, on the other, (2) an “incomprehensible enigma” relating “the end of European Jewry.” White observes that Hillgruber’s work “does not violate any of the conventions governing the writing of professionally respectable narrative history,” and yet the meaning and functions of his subjects are shifted within the same text “by narrowing the focus of a particular domain of the historical continuum, casting the agents and agencies occupying that scene as characters in a dramatic conflict, and emplotting this drama in terms of the familiar conventions of the genera of tragedy” (2001, p. 379). Although perpetually subject to arbitrary influences, a historical narrative is subsequently also subject to possibilities.

In appropriating White’s notion of emplotment and Foucault’s truth regime, I attempt theoretical approach that is not only conducive to recasting narratives, but also is sensitive to the political implications of doing so. This means recognizing the particular confluence of historical and scientific discourses that have situated STEM as a Romance, beginning with the launch of Sputnik, and ending with a need-statement promising relief from crisis. Throughout I indicate narrative opportunities that are capable of supporting other tellings and other interests.

CHAPTER 3

METHODOLOGY

The sources that inform this study are those I have encountered during the previous year (2013), independently researching STEM literature. These sources may be generally categorized as publications from government agencies, the popular press, academic sources, and corporate sponsored publications, which include speeches, proposals, annual reports, requests for proposals, reform plans, mission statements, and term agendas. I have selected these sources by pursuing references, following advice from my committee, and seeking credible sources for the resolution of conflicting claims. The accumulation of texts has developed in a non-linear fashion and the categories I describe here are *post hoc* constructions. My broad reading of STEM literature has made it possible to recognize connections between otherwise disparate topics, such as immigration, pacifism, ecology, and curriculum reform. My efforts to categorize, interpret, and describe STEM discourse, with its various intersections, have been conceived as an experimental response to the problem of liberation: one valuing situated mobility among possibilities, rather than a specific version of would-be authoritative truth.

Early in my efforts to organize these readings, I perceived three rationales through which STEM advocates attempt to justify their projects: economic competition, military dominance, and social equity. In my writing, however, I have collapsed economic and militaristic rationales into a single category, “competition” because of their similarities. Indeed, in some texts, it can be difficult to distinguish whether the authors are concerned with dollars or detonators when arguing the importance of STEM for sustaining

American competitiveness. Subsequently, this writing describes “competition” and “equity” as the primary rationales occurring in STEM discourse. Furthermore, theoretical cosmologies have been selectively cherry-picked for some concepts, without great concern for the perhaps orderly and cohesive worldviews from which they have been plumbed and “decontextualized.”[12] The subsequent pastiche of citations and commentary poses a departure from common scholarly conventions because, as Foucault and White have illustrated, these conventions are incapable of delivering truths that transcend their immediate politics.

[12] I am suspicious of appeals for “contextualization,” which can have the unnecessarily conservative effect of prematurely suppressing otherwise viable interpretations under the weight of preceding tradition. Or, in a more famous, declarative formulation of the problem: "there is nothing outside the text" [*il n'y a pas de hors-texte*] (Derrida, 1967).

CHAPTER 4

STEM NARRATIVE RATIONALES

In considering STEM rationales as manifestations of a truth regime that can be formally analyzed as literary discourse, I endeavor to develop a partial map of major nodes of discursive power and possibility in STEM. The pervading truth of STEM history is emplotted as a Romance whereby a patriotic nation responds triumphantly to the provocations of an Evil Empire. In his second State of the Union Address, President Obama provides an example when prefacing his proposals to invest in a number of STEM initiatives (i.e. "biomedical research, information technology, and especially clean energy technology") with a summary of the Sputnik Narrative:

> Half a century ago, when the Soviets beat us into space with the launch of a satellite called Sputnik, we had no idea how we would beat them to the moon. The science wasn't even there yet. NASA didn't exist. But after investing in better research and education, we didn't just surpass the Soviets; we unleashed a wave of innovation that created new industries and millions of new jobs. (White House, 2011)

This Sputnik narrative is invariably paired with any combination of competitive and/or equity rationales for the advancement of STEM initiatives, both in education and elsewhere. Through strategic emplotments and modifications of emphases, however, other narrative possibilities can be imagined and explored. I return to this concern in my conclusion.

Economic and/or Militaristic "Competition" Rationales

Among Sputnik narratives, perhaps the most repeated rationale for STEM is that of "competition." In the State of the Union speech cited above, for example, president Obama positions Americans within "our generation's Sputnik Moment," as defined by a

challenge to “reach a level of research and development we haven’t seen since the height of the Space Race” (White House, 2011). Other contemporary appeals are similarly urgent when warning that a lack of educational funding might damage “America’s ability to compete for jobs on the global marketplace” (Rising Above the Gathering Storm Committee et al., 2010, p. 26) and characterizing the task of “neutralizing today’s threats -terrorism, biological and chemical weapons, nuclear proliferation, and cyberwarfare- [as] an intensely scientific undertaking” (Gulledge, 2011, p. 156).[13] The often shrill tenor of these testimonies resonate with those of NDEA advocates during Space Race-era Senate Preparedness Hearings. Consider, for example: Dr. Vannevar Bush’s urging that Americans “wake up to the fact that we are in a tough, competitive race” (Divine, 1993, p. 65); Sen. Lister Hill’s urging that “We Americans know we must mobilize our Nation's brainpower in the struggle for survival” (Clowse, 1981, p. 83); and Dr. Edward Teller’s testimony that “the Russians are pulling-ahead of us in science [because] they drive their children on toward a very solid education, particularly in science and math, and they drive them on in a very merciless manner” (Spring, 1992, p. 167).

As a discursive strategy, president Obama’s Sputnik Moment, proposes a historical template for future action. It is a history for the present. The construct, "Sputnik Moment," as President Obama describes it, proposes to routinize ennobling crises against which each generation of Americans must measure itself. The President arranges his

[13] In a report published by the Center for Strategic and International Studies (and featuring an image of Sputnik on its cover), Lewis (2006) summarizes the confluence of anxieties concisely: “Basic research in the physical sciences and engineering is the area for investments that will yield greater returns and comparative advantage, in part because of their importance to military technology and in part because they are very often the source of enabling technologies for all other kinds industries and other fields of research. The investment in basic research in the 1970s and 1980s provided the intellectual capital for the high-tech economic boom of the 1990s. This funding is not being renewed at the same level now, suggesting that the well of innovation may begin to run dry in the next decade” (p. 21).

particular STEM initiatives (e.g. a budget proposal for investment in biomedicine, information technology, and clean energy) within a defining test -a collective rite of passage for a generation. In this regard, the "Sputnik Moment" assumes a character that transcends rational judgment, not only allowing an audience of Americans to disavow the more problematic legacies of Cold War terror,[14] but also confronts us with a ritual wherein ultimate success or failure depends on one's performance as a patriot within "a drama of the triumph of good over evil, of virtue over vice, of light over darkness" (White, 1973, p. 8). These last words are borrowed from White's definition of a Romance.

The story, although cast in a mythic register, is an imperfect Romance (White, 1973). The major distinction between mid-20th Century and contemporary Sputnik moments are the slipperiness with which placeholders for Soviet Russia are suggested (by proximity, for example), as when President Obama mentions that "nations like China and India [have] started educating their children earlier and longer, with greater emphasis on math and science. They're investing in research and new technologies. [...] The competition for jobs is real" (White House, 2011). The threat is real.

But the summary existential threat often attributed to the Soviet Union has no modern analogue, whatever might be said about a post-9/11 cultural withdrawal from The Age of Irony (Hirschorn, 2011). Subsequently, American public discourse has no single nemesis capable of sustaining the dualistic, good vs. evil narrative on all fronts:

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[14] For example, Moore (1996) cites a number of causes for protest used by scientist-activists during the 1950s through 1970s: "The war in Vietnam and MIT's involvement with the military were not the only reasons for faculty involvement; the development and deployment of the anti-ballistic missile over the objections of scientists, President Nixon's proposal to cut basic research budgets, and the revelation that the National Institute of Health and the National Science foundation were still blacklisting scientists with liberal and radical political views were all important in prompting scientists to take political action" (p. 1611). These are not discussed in Sputnik narratives.

economic, militaristic, and social.[15] There are multiple implications here. First, contemporary appeals for STEM initiatives use the Sputnik narrative as a historical symbiote to achieve their mythic register. Senator Michael B. Enzi concisely illustrates this technique: “Fifty years after Sputnik, the United States is in another equally important race that will define our leadership” (Brainard, 2007, p. A22). Or, in another example, Brian Kelly, Editor and Chief Content Officer, U.S. News & World Report, deploys a similar narrative when discussing a “skills gap” between unemployed Americans and STEM labor demands:

> There is evidence that this skills gap is part of the structural drag on the U.S. economy. Americans were shocked when the Russians put the Sputnik satellite into space in 1957 and grabbed a lead in global technology. We responded with a massive push to upgrade math and science education. (STEM Connector, 2012, p. 23)[16]

The historical analogies are multiple and replaceable, but –like all analogies- are also imperfect.

Second, perhaps to account for slippages among discursive fields and actors (e.g. as when the economic enemy is China, but the military enemy is “terrorism”), “competition” appears in Sputnik narratives as an abstract rationale for STEM as a solution to an unspecific struggle against an unspecific enemy. Consider, for example, the history presented by the Center for Strategic and International Studies in a report that,

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[15] Consider, for example, the vaguery of what is likely to be our closest contemporary analog, "al Qaeda-linked terrorism" and The War on Terror. The enemy is known by unspecified “link” to a diffuse organization and an ill-defined cause. The inability to articulate an unselfconscious characterization of “the enemy” indicates an ideological frailty that better recommends an attitude of ironic distancing than homicidal devotion.

[16] As described on its website, STEM Connector was launched in 2011 and coordinates with 3,000 participating entities, including program directors, government agencies, K-20 providers, and industry partners “to bridge the gap between STEM organizations and increase communication and collaboration in the STEM community [...] The Project especially focuses on increasing communication among programs that work to advance minorities and women in STEM” (STEM Connector, 2014).

after citing Sputnik and the NDEA, argues for "basic research in physics, math and engineering," in response to "long term strategic challenge created by global competition that puts U.S. security and the national interest at risk" (Lewis, 2006, p. 4). It is an alarmist discourse that warns against enemies that may or may not yet exist, to pose a military and/or economic threat to the nation, and for which no evidence should be considered evidence.[17] As Lewis (2006) noted, "The Sputnik surprise showed America the dangers of resting too long on past successes" (p. 6). Although exceptionally flagrant, this rhetoric is illustrative of a common tendency in Sputnik narratives toward preoccupation with undefined menaces.

Finally, and obviously, this game of associating narratives and substituting threats for the purposes of political agitation can be sustained indefinitely. But the flooding of the discursive field with Romantic accounts linking STEM initiatives to a mythic Sputnik has neither been fully achieved nor embraced. For example, David Goldston (2008) a former Staff Director for the House Science Committee and columnist on science policy for *Nature* has criticized the Sputnik narrative as having "left the scientific community far too easily discouraged when it confronts the real political world and needlessly short of stories to deploy on its own behalf" (p. 561). In their overview of STEM-specialized schools in the U.S., Thomas and Williams (2010) echo this frustration, concluding:

> Historically, the call for enhanced STEM education has to a large degree been reactive: workforce crises, perceived threats to national defense, international economic competition. Perhaps the arguments for increased support for STEM education should be recast. Instead of identifying talent to stave off or react to crisis, STEM education (and education in all fields where students demonstrate talents and interest) might better be recognized as a means of realizing human potential. (p. 21)

[17] Stated most explicitly: "Although the damage might not appear for years, America is not making the R&D investment decisions needed to sustain its strength and competitiveness" (Lewis, 2006, p. 3).

This last statement raises the question of alternative discourses, which will be discussed in the following section.

Countering Competition Rationales

There are a number of criticisms that can be leveled against a Romanticized Sputnik narrative that alleges a valorous, STEM-centric American response to Soviet provocation. To begin, the NDEA, which is usually cited as the major legislative response to Sputnik, did not pass until nearly a year after the launch of Sputnik. During these eleven months between 4 October 1957 and 2 September 1958, a range of arguments were produced that might be presented in evidence of political disagreements, maneuverings and concessions that contradict the uncalculating unity appearing in Sputnik mythology. For example, criticisms against the legislation included conservative objections that funding abuses would follow from the NDEA's overly-broad eligibility criteria; that domestic market dynamics would be grossly distorted by injections of federal funds[18]; that currency inflation and national debt would increase; or that federal

[18] Of course, conservative critics were correct to predict that federal involvement in schools would only increase during the preceding decades. However, decades later, this mode of mid-Twentieth Century conservative opposition to the NDEA is rarely situated as an ideological tenant, except perhaps within Libertarian ideology: "Despite the NDEA's failure to improve mathematics and science achievement, Congress and the president decided to repeat the same ineffective strategy nearly half a century later, with the America COMPETES Act of 2007. It is not clear why legislators believed the results would be different this time around. It is not even clear that legislators were aware of the earlier failure of the NDEA" (Cato Institute, 2008). Indeed, "Today, few legislators oppose the general principle of federal involvement in schools" (Anderson, 2007, p. 9). This change is often attributed to passage of the NDEA, since previously "...only about 20 research-intensive universities receive federal research funds [but] today, about 100 such universities exist" (Brainard, 2007, p. A22) And, meanwhile, lobbyists for STEM Education continue to agitate for increased federal funding: "STEM schools may operate under the purview of either a college or university or under local boards and district stakeholders. Local school districts are often reluctant to fund these specialized schools due to high costs of laboratory equipment and supplies, because it can cost anywhere from $11 million (to refurbish an existing building) to over $50 million to build a brand new STEM school. To continue creating these specialized schools, there must be increased federal funding and institutional partnerships with local universities and national laboratories" (Thomas & Williams, 2009, p. 19).

dollars from the NDEA might impose an unconstitutional, controlling influence over school systems and their educational policies (Clowse, 1981). Joining in with conservatives, secularist groups argued that funding for parochial schools would violate separations between church and state (Clowse, 1981). Southern Democrats, meanwhile, were apprehensive that access to NDEA funding might be withheld from those states unwilling to enforce the recent (1954) *Brown v. Board of Education* decision.[19]

By calling attention to these objections, the mythic urgency that supposedly spurred Washington to action may be challenged and used to redefine passage of the NDEA not only as a product of political compromise, but, furthermore, mired in a state of "lassitude" by the summer of 1958 (Clowse, 1981). Or, as President Eisenhower more hearteningly phrases it in an interview dated May, 1958: "I do believe that the United States has now caught its breath and is not quite so apt to use the words 'urgent' and 'critical,'" (Divine, 1993, pp. 169-170). [20]

The problem-solution framing that typically accompanies Sputnik narratives, arguing that the NDEA addressed a real national deficit in STEM expertise, may also be challenged. Clowse (1981), for example, arranges an opposition between the claims of

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[19] Of course, the NEDA would pose no challenge against Jim Crowe. Section 102 of the NDEA is explicit that no federal authority would "exercise any direction, supervision, or control over the curriculum, program of instruction, administration, or personnel of any educational institution or school system." Southern policy of Massive Resistance, would proceed according to its notoriously leisurely timeline, "with all deliberate speed" (Brown II). Many uncooperative districts did not officially pursue integration until the 1970s (Rothstein, 2013). During more recent decades, there has been growing concern that school districts throughout the United States have regressed to a *de facto* racial segregation that has effectively rendered the original Brown ruling irrelevant (Bell, 1992).

[20] Eisenhower (February 25, 1959): "...I again assure you that just spending money does not make us stronger. Indeed, if you spend too much money, you will make us weaker. That is when the nicety of judgment comes in--what do we need; get that; get that by all means, and get no more. Remember, our system is a balanced one. We should not concern ourselves so much with one single item. Somebody makes a demagogic talk about a missile, or somebody else about a different submarine or a piece of radar. You have got a whole level of balanced types of equipment, training, organization, and strategy that we believe fits our system." According to Clowse (1981), Eisenhower "took pains to refer repeatedly to the bill as 'short-term emergency legislation in education'" (p. 127).

STEM professionals and those of STEM educationalists when recounting the testimonies presented during the 1958 preparedness hearings:

> Representatives of engineering groups and some of the scientific bodies, then, made quite a contrast to the education lobbyists at the hearings. The latter tended to ask for unencumbered, generous amounts of money and public trust in them to accomplish whatever was required of the schools and colleges. The former often rejected (or at least qualified) the conventional wisdom of the sputnik crisis [...] their testimony cast doubt on the idea that America lacked personnel in these fields and, therefore, must produce them rapidly, using the federal government's aid. (p. 86)

In a manner that may be equally problematic for the authenticity of so-called "Sputnik hysteria," other authors have reversed this arrangement by positioning STEM professionals as the primary promulgators of a STEM expertise deficiency discourse.

> Only with determined lobbying by physicists *and others* did Sputnik and associated claims about a "manpower gap" vis-à-vis Soviet scientists become transformed into a political event requiring a specific political response. (Kaiser, 2006, p. 1247; emphasis mine)

Here, the phrase "and others" may function as a technique for concealing the "education lobbyists" mentioned by Clowse (1981). Using this strategy of semiotic gerrymandering, the category of physicists (i.e. STEM professionals) may be solely occupied by such outlying public figures as Vannevar Bush, Edward Teller and Wernher von Braun. Neither conclusion depends on an extraordinary methodology or a mode of argumentation that is "counterfactual." The choice is not innocent and the historian must choose.

Another narrative strategy could be to recover abandoned alternatives that once might have functioned in place of competition discourses. For example, Clowse (1981) mentions an ambivalence experienced by "most reformers and, to some extent, the

educational establishment" who, during the mid-1950s, became increasingly sensitive to discursive links between schooling and national security:

> Their ambivalence toward altering education specifically to meet the demands of an international power struggle sometimes led reformers to use rationales more limited or acceptable than the obvious one. *The imperative against 'waste,'* a maxim familiar to many generations of Americans took on fresh meaning. Certain sets of figures appeared time and time again to illustrate that a deplorable 'waste' of talent was occurring. The two hundred thousand able high school graduates who failed to enter college –one third of those qualified to go- because of need or low motivation were thus being 'lost' to the nation. (pp. 37-38; emphasis mine)

Indeed, this re-centering of concerns for wasted talent and intellectual thrift is perhaps what Thomas and Williams (2010) mean when they argue for a different STEM rationale: "Instead of identifying talent to stave off or react to crisis, STEM education [...] might better be recognized as a means of realizing human potential" (p. 21). Of course, if the decline of thrift is necessarily linked to larger economic and ideological shifts in the United States toward consumerism, [21] then such a resurgence might not be feasible without cataclysmic historical transformation.

Recall President Obama's characterization of America (and STEM experts) at the time of Sputnik's launch as unprepared: "The science wasn't even there yet. NASA didn't exist" (White House, 2011). This characterization of American expertise as outclassed by Sputnik engineers is indispensable to standard Sputnik narratives, which favor a Skinnerian symmetry between the "hysterical" stimulus of Sputnik and massive response of STEM investment; as a recent, popular-media documentary illustrates, however, even here the Sputnik narrative may be called into doubt:

[21] The shift to a so-called consumer society is commonly recognized as one of the defining cultural developments in contemporary societies: "Between 1810 and 1945 the United States became a consumer society whose inhabitants used the mass market to make their daily lives, from personal hygiene to communal leisure" (McGovern, 2006, p. 3).

> On September 20, 1956, more than a year before Sputnik, the Redstone [rocket] with extra stages, called Jupiter-C, is successfully launched, carrying a dummy top stage. Had it carried a satellite instead, history would be different. (Hoffman et al., 2008)

This representation of Sputnik as allowed to be first not only recovers American historical agency, but also allows an appealingly broader story to be told. Here, Eisenhower's delay of an American satellite is part of a grand strategy to strengthen American legal credibility when advancing a policy of international access to outer space. In this way, Sputnik's orbit over multiple national boarders signifies the springing of a global trap intended to extract tacit Soviet support for a "Freedom of Space" policy. [22] The historical denouement occurs in June of 1959, with the winking camera shutter of an American spy satellite, CORONA, as it coolly photographs the terrestrial activities of Russian without risk of provoking legal conflict.

Another image must be explained for this narrative to work, however: what can account for the common portrayal of an American population consumed with "sputnik hysteria"? Here, we turn to the influencing machine, "the media." In telling such a story, Kaestle and Smith (1982), cite popular contemporary texts like Life Magazine's five-part series, "Crisis in Education" (24 March 1958 - 21 April 1958) as well as Admiral Hyman Rickover's *Education and Freedom* (1959) and James Conant's *The American High School Today* (1959), all of which can be summarized as arguing for a "causal relationship between schooling and the space race" (p. 329). In a similar fashion, a steady stream of New York Times articles or any number of remarks from Lyndon Johnson

[22] A top-level policy document from National Security Council (partially declassified 10 December 1981) illustrates: "Furthermore, a small scientific satellite will provide a test of the principle of 'Freedom of Space.' The implications of this principle are being studied within the Executive Branch" (National Security Council, 1955)

might be cited.[23] The rhetoric is introduced by an insurrectionist cabal of educationalists, journalists, and politicians who opportunistically distort the significance of Sputnik to promote a new national agenda and themselves as its leaders. Indeed, as several commentators have noted, by the end of the 1940s the old educational regime (i.e. the Progressivist Life Adjustment Movement) had has been subject to "a blizzard of criticisms" and "fizzled out" (Klein, 2003). Ravitch (2000) draws similar conclusions: "Progressive education was forced into retreat in the 1950s, and even became the butt of jokes and vitriol" (p. 361). The critics are ready to fill the subsequent political vacuum:

> A cluster of forces and circumstances encompassing more than just the soviet challenge shaped the resulting [NDEA] legislation. It was a 'composite law with provisions to suit a variety of pressure groups.' Educators and their political supporters had been proposing its components for years. (Clowse, 1981, p. 144)

Among the conspiring forces would include advocates of the New Math Movement (Klein, 2003) and advocates of the specialized scientific education that Roberts (2007) calls Vision I.

Kaiser (2002) presents a good example of this approach while recovering the conservative discourse concerned with the disruption a presumed homeostatic balance between market supply and demand:

> And yet it still generated sufficient hot air—from high-ranking officials, widely read journalists, and influential physicists—to inflate American science classrooms far beyond any previous enrollment patterns. Indeed, the physicists' public relations campaign, aided by an eager press, buoyed an *unnaturally high demand for physicists* for the next decade and a half, ensuring that their discipline would grow faster than any other field. (Kaiser, 2002, p. 1239)

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[23] Consider headlines like "Science Leaders for Nation Urged: Head of Cooper Union Says Technicians Should Guide Society They Created" (12 December 1957), or "U.S. Science Unit Advises Doubling Education Funds: Presidential Panel Reports Wider Training Is Vital to Survival of Nation" (24 May 1959), or any one of Johnson's various, alarming comments: "Soon [the Russians] will be dropping bombs on us from space like kids dropping rocks onto cars from freeway overpasses" (Kuhn, 2007) or "In Texas, we live close to the sky -and now, in some ways, our skies seem alien" (*Sputnik Mania*, 2007).

Political objections to the perceived impositions of federal investment in education became rare during the Bush administration (Anderson, 2007), perhaps as a result of conservative support for No Child Left Behind. Nonetheless, recent developments in conservatism (e.g. the ascendancy of the Tea Party), may renew their practicality and reverse Barry Goldwater's (1958) famous warning about federal aid to education, "If the camel once gets his nose in the tent, his body will soon follow" (p.17290)

Social Equity Rationale

The social equity rationale for STEM generally argues that education and employment in STEM fields can improve material and social conditions for women, minorities, and people with disabilities in the United States.[24] Whereas the economic and militaristic rationales can be easily recognized, for example, in the stated mission of the National Science Foundation (NSF), "To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense" (National Science Foundation [NSF] Act, 1950), the social equity discourse is better identified with other developments in American politics, such as those constitutive of the Civil Rights Movement (e.g. Enlightenment political philosophers, abolitionist polemics, reactions to anti-Jim Crow Soviet propaganda, etc.). In this respect, the social equity rationale relies on looser associations with the stated aims of Sputnik-era STEM legislation. After all, the NDEA's commitment to social equity is questionable, given its compatibility with a "best and brightest," elitist discourse (i.e. Roberts' Vision I) and, more directly, its deliberate

[24] For example, the STEM Connector (2012) states: "approximately two-thirds of our future workforce — women, people of color, and people with disabilities— remains minimally tapped as a source of future engineers" (p. 125).

formulation to avoid so as to avoid entanglement with Civil Rights discourses. Rather, it draws upon what is perhaps the most evident modern legacy of the Civil Rights Movement: identity politics.

Appeals to social equity often begin by identifying injustices in demographic disparities, both within the U.S. and STEM fields, as recognized among representatives of normative identity categories (e.g. race, gender, class, dis/ability). In racial discourse, statements of this kind read as follows, "Half of all non-Hispanic Asian workers with STEM degrees have STEM jobs, compared to 30 percent of Hispanics and non-Hispanic Black and American Indian and Alaska Native workers" (US Department of Commerce a, 2011, p. 1). In gender discourse, an analogous statement might be phrased as, "although women fill close to half of all jobs in the U.S. economy, less than 25 percent fill STEM jobs" (US Department of Commerce b, 2011, p. 8). Or in disability discourse, the claim might be, "Regardless of when disabilities were acquired, persons with disabilities are underrepresented in the science and engineering workforce compared to the population as a whole" (NSF, 2013, p. 10). These figures have the general narrative function of representing conflict. Meanwhile, the ubiquity of disparity figures in particular can be understood in terms of their potential for juridical enforcement through the legal status of "protected classes" (e.g. the Civil Rights Act) and the relative demonstrability of violations of "proportionality clauses" (e.g. Title IX).

The next narrative task is to establish the desirability of accessing STEM credentials, knowledge and employment as a solution for "the uncivilized of the world" (White, 1978, p. 269), which is to say: populations that are systematically marked and othered in the meaning systems of a civilization. This can be done, as is suggested in the

title of one U.S. Department of Commerce report, by arguing that *Education Supports Racial and Ethnic Equality in STEM*; here, education is situated as "a gateway to high-quality STEM jobs" (U.S. Department of Commerce, 2011a, p. 8). Such arguments may characterize the desirability of STEM jobs in terms of prestige, mobility, social capital and societal benefits,[25] but most often stake their appeal on increased employability and salaries:

> In 2012, the US STEM workforce surpassed 7.4 million workers and it is expected to grow significantly through 2018, to an estimated 8.65 million workers. (STEM Connector, 2013)
>
> If you include all jobs directly using STEM skills, including those in health and medicine, STEM jobs represent 70% of the highest 150 paying jobs in the country. (National Alliance for Partnerships in Equity, 2013)
>
> Even when women earn a STEM degree, they are less likely than their male counterparts to work in a STEM field even though STEM jobs pay more and have a lower wage gap: 92 cents on a dollar versus 75 cents in other fields. (Girl Scouts Blog, 2014)

This last example also illustrates how the promises of STEM can be linked to a larger promise of social equity. In this respect, the elimination of demographic disparities within STEM acquires a synecdochal, even salvific function whereby the correspondence between national demographics and STEM demographics becomes a moral mission for recovery from ongoing inequities in American society. Some have even expressed an explicit preference for this mission before, for example those of the competition rationale:

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[25] In a speech presented at Women's Hall of Fame, Mary Sue Coleman, the former president of the University of Michigan, represents STEM diversity as a social good that produces better solutions with increased acceptability: "social scientists teach us that collective decision-making processes are more likely to lead to outcomes that the whole community can support if decision-makers have had a chance to consider an array of diagnoses of 'the problem requiring action.' That argument alone is sufficient justification for broadening and diversifying the pool of those who do science in this country" (NSF, 2005, p. 78).

> First, it is *not* about the total number of scientists and engineers the nation may or may not need. It's easy to get distracted by trends and statistics cited in the news and debates about whether the demand for science, engineering and technological workers is greater or less than the supply. It *is* about including a larger proportion of women, underrepresented minorities and persons with disabilities in the scientific workforce, no matter the size of that workforce. Whatever the numbers turn out to be, we need a robust and varied mix, and that means broadening participation. (NSF, 2005, p. 8; emphasis mine).

Of course, large constituencies of Americans would not perceive such a recovery as necessary or even desirable (e.g. consider the introduction of a term like "race card" into public discourse); there is no reason, however, that equity rationales and competition rationales cannot be paired. And, indeed the popularity of STEM discourses might depend upon this potential for selective affinities among of rationales:

> Enabling and encouraging *equitable* access to premium education is critical to ensuring that America maintains a wide and *diverse* source of STEM professionals that help to advance U.S. innovation and global *competitiveness*. (US Department of Commerce, 2011a p. 8; emphasis mine)

Among the major participants in the STEM equity rationale is the NSF, which has developed a program of "embedded diversity" to redress institutional practices within the NSF that might reproduce societal disparities in STEM. The Committee on Equal Opportunities in Science and Engineering (CEOSE) advises the NSF on ways to increase diversity in STEM: "to encourage full participation by women, minorities, and persons with disabilities in science, technology, engineering, and mathematics" (NSF, 2005, p. 2). Finding "Overall, NSF's STEM demographics are higher in diversity than national STEM demographics," CEOSE credits a number of NSF policies for this success (NSF, 2005). In a dramatic example, a 2002 policy requiring that all grant proposals describe the anticipated "broader impacts" that funding will have for large segments of the U.S.

population:[26] “Initially, the broader impacts criterion was ignored by many grant applicants and reviewers"; however, following policy enforcement, "Over 90% of the reviewer evaluations in 2003 addressed the broader impacts criterion, as compared to 84% in 2002 and 69% in 2001” (NSF, 2005, p. 26).

Causes of these disparities are typically attributed to the impersonal operation of nonetheless biased and determining conventions: “systemic discrimination.” Other terms like *de facto* racism, the chilly climate (Hall & Sandler, 1982), the hidden curriculum, gatekeeping, and the social model of disability, provide conceptual language for grouping institutionalized and systemic practices that reproduce discrimination. Using gendered discourse in STEM as an example, such language may manifest as commentary on “girls’ reluctance to pursue computing as early as elementary school, [resulting from] discouraging parents, inadequate resources for teachers and a lack of exposure” (Miller, 2013). Or, as the Committee on Equal Opportunities in Science and Engineering (2004) phrases it, “the early attrition of females and minorities from a STEM pathway [resulting from] a lack of qualified mathematics and science teachers, discouragement by guidance counselors, the perceived irrelevance of science and mathematics to their daily lives, a lack of public understanding of science, and peer pressure” (p. 84). In disability discourse, the statement might read, “teachers and professors are frequently unable, unprepared, or otherwise ill equipped to recognize and address the needs of students with disabilities [who may] encounter negative attitudes from faculty and peers [...] are

[26] For instance, a report to the National Science Board on the National Science Foundation’s merit review process defines "broader impacts" and prompts applicants to answer: "How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)?” (National Science Board, 2005, p. 18)

commonly discouraged from pursuing STEM degrees [and] many are not fully included in more rigorous learning activities such as labs" (Moon et al., 2013, pp. 12-13).

This social equity rationale, with its problem-solution framing comprised of (a) linking demographic disparities in STEM to ongoing social inequities and (b) arguing the desirability of opportunities available through STEM as a means of achieving social goods, commonly coincides with an image, the *STEM pipeline* (see Figure 1). This image typically begins with an aggregate population (e.g. all 9th grade students in America during 2001) and represents all subsequent deviancy from pursuit of a STEM field as a "leak." In an international study of American and Australian students, Watt et al. (2006) present the archetypal thesis within this research genera: "At each successive educational level, girls are more likely than boys to opt out of the so-called 'STEM' fields – science, technology, engineering, and maths" (p. 642).

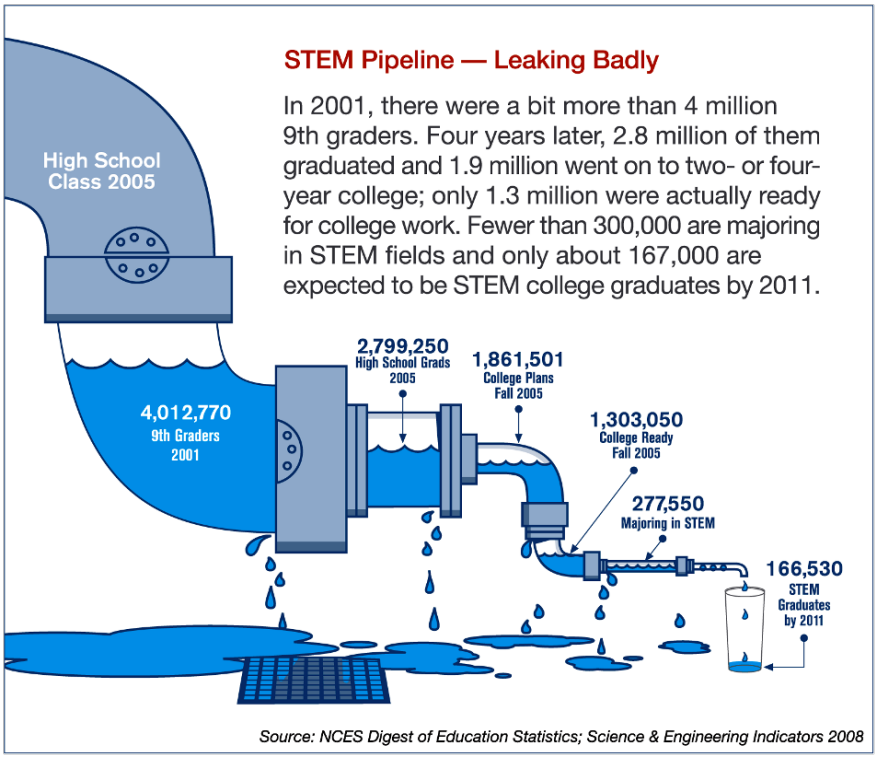

Figure 1. STEM Pipeline (Walter, 2013)

Although the NSF makes frequent use of the pipeline metaphor, CEOSE authors criticize the image as inappropriate –not for its crass representation of children as product to be moved, or for its doubtful suggestion that a STEM career is the default interest of all members within a given population- but because the pipeline cannot describe the market potential of STEM education outlets: “It emphasizes attracting students into the STEM ‘pipeline’ when they are young, and spotlights the points at which ‘leaks’ occur, differentially draining away individuals from underrepresented groups” (Committee on Equal Opportunities in Science and Engineering, 2004, p. ix). [27] There are ways of challenging this rationale, as will be discussed in the proceeding section.

Countering the Social Equity Rationale

There are several ways to counter the STEM equity rationale, outright, on strictly ideological grounds. Critical Race Theory (CRT), for example, holds as a tenet that "racism is permanent" (DeCuir and Dixson, 2004). Integral to American governance and identity, racism "is a critically important stabilizing force that enables whites to bind across a wide socio-economic chasm” (Bell, 1993, p. 571). In this respect, a STEM equity initiative that is supported by major U.S. institutions can only promise illusions when offering blacks "a chance at well-paying professions with prestigious companies, as well as the ability to enter into the field as an entrepreneurs and leaders of technology"

[27] An alternative, “pathways” metaphor, is intended to resolve the problem by suggesting a more comprehensive strategy including attraction, retention, persistence, attachment: “Today, many efforts to make science and engineering more inclusive are paying attention instead to the multiplicity of ‘pathways’ by which persons from underrepresented groups can enter and progress through STEM careers” (Committee on Equal Opportunities in Science and Engineering, 2004, p. ix). The pipeline image remains dominant in STEM literature, however.

(Black Girls Code, 2013). Rather, any apparent benefits for blacks are inevitably shown to have operated according to a principal of "interest convergence," whereby "the interest of blacks in achieving racial equality will be accommodated only when it converges with the interests of whites" (Bell, 1980, p. 523). In this respect, "progress" is merely (a) coincidental to white interests, (b) relatively limited, and (c) destined to "slide into irrelevance" (Bell, 1992, p. 12). As will be illustrated, discourses challenging the STEM equity rationale do supply adequate material to sustain such a reading. [28]

Free market ideology also poses a readymade objection to the STEM equity rationale, claiming that social equity is best achieved through the free exchange of goods and services by presumably rational actors who, through civic consumption, vote with their feet (Tiebout, 1956, pp. 416-424). According to this argument, STEM initiatives and funding disrupt an otherwise organic progression of markets and societies toward the best of all possible worlds. The social role of government is avoidance of market interference, while "the social responsibility of business is to increase its profits" (Friedman, 1970). Recognizing both modern STEM initiatives and passage of the NDEA as similarly disruptive of markets, this discourse is generally satisfied to uphold the Sputnik narrative in order to criticize both the NDEA and STEM:

> Before making any dramatic changes in our supply of engineers, we need a better understanding of the demand side of the equation. Otherwise, we risk unintended

[28] There are some particularly CRT objections to STEM initiatives, too. For example, appeals to assemble "the finest minds in the nation" (Clowse, 1981, p. 86) would position the issue in neutral terms, creating space for ideological biases (i.e. de facto racism) to proceed unchecked, when metrics of these qualities like "intelligence" are regularly found to be unfair, inaccurate and especially predisposed to favor privileged identities (Steele & Aronson, 1995). Discourses centered on the "digital divide" and "new digital divide" describe some of these ideological biases whereby prevailing social narratives continue to code Whiteness with progress, technology and civilization, and Blackness with nature, primitivism, and pre-modernity (Hobson, 2008). More broadly, CRT discourses have served as a model for promoting other identity politics discourses to include: not only race (Boellstorf, 2008), but also gender (Gee & Hayes, 2010; Tobias & Fletcher, 2010), nationality (Hongladarom, 2000), language (Gorski & Clark, 2002a), and dis/ability (Gorski & Clark, 2002b).

> outcomes that can distort labor markets and the attractiveness of these fields for years to come. The boom–bust cycle of engineering employment following Sputnik made engineering an unattractive career opportunity for many years following the dramatic employment declines in the late 1960s and through the 1970s. More recently, the expansion of science doctorates has led to a decline in the appeal of those degrees to prospective students. (Salzman & Lynn, 2010, p. 16)[29]

The social equity rationale can be less abstractly challenged through direct consideration of its premises: (a) disparities indicate inequities and (b) STEM provides a means of rectifying these inequities. I phrase the first premise in neutral terms not only to illustrate that concern for proportionality can be applied to any socially recognized identity category (albeit too rarely in intersectional terms[30]), but also to emphasize an appeal to neutrality that is consistent with those found in both legal and scientific discourses. This

[29] The dissolution of the USSR and the end of the Cold War, corresponds with a period optimistic rhetoric. The discourse of "economic conversion," popular during the early 1990s, calls for a conversion of military funding, technology, and expertise for civilian purposes, promising: “An S&T [Science and Technology] agenda based on civilian national needs would, by its very nature, be broader and more balanced, with greater overall benefits to the economy than the current one dominated by the requirements of the military and high-tech sectors” (Yudken and Black, 1990). This effort is generally considered unsuccessful, however, since "from 1990-1995, defense industry employment fell by a half million people," while many highly specialized military contractors and scientists were left without jobs: on average, only about 35% commercial and military mergers and acquisitions were successful (Gansler, 2011, p. 36). Although efforts to convert engineers from military to civilian work came at a loss of many jobs, the problem did not persist. Indeed, in an essay predating the wars in Iraq and Afghanistan, Oden and Markusen (1996) argue that economic conversion will not be possible without more serious efforts to redirect federal funding away from military spending. In an curiously prescient remark, the authors note that the Clinton Administration’s "Bottom-Up Review" of the projected defense budget had necessarily "recommended a defense plan premised on fighting two wars simultaneously” (p. 279). This criticism, of course, would become moot for many following September 11, 2001. Otherwise, conversion does infrequently appear within pacifist discourses advocating an end to what president Eisenhower famously characterized as “military industrial complex” in his farewell speech to the American people, broadcast on 17 January 1961 (Gansler, 1996).

[30] Critical theorists have long documented ways in which gender and race are used to determine class (Gimenez, M., 2001), more recent discursive trends have complicated this tradition by decentering class and demonstrating a reciprocation among social identities (Collins, 1993). Advocates of this position recognize identities as multiple and mutable insofar as the meanings of a person are likely to depend on a complex interfacing of multiple identity-markers as well as social circumstances; subsequently, Collins (2009) can describe her style of dress using such terms as "social blackening" or "honorary whiteness." Neither mono-dimensional nor stable, identity is managed according to "a complex calculus as to how much whitening clothing and behavior may be needed from one situation to the next" (p. 42). This critical approach, intersectionality, is attributed to Kimberlé Crenshaw (1989), who argues "Because the intersectional experience is greater than the sum of racism and sexism, any analysis that does not take intersectionality into account cannot sufficiently address the manner in which Black women are subordinated” (p. 140).

scientific ideal of discerning truth through dispassionate assessment has not only been an inspiration to the policies and beliefs underpinning American governance, but also serves as a basis for legitimacy in a society that avows pluralism. As manifested in law, this "neutral principal" remains so integral to contemporary U.S. politics that its operation may be recognized whole spectrum of politics, ranging from efforts to redistribution of wealth, to the regulating markets, to the advocacy of civil rights (Bell, 1993). Indeed, in a passage describing arbitrary influences in science, Moore (1996) simultaneously illustrates how this convention of scientific processes is conflated within the conventions of larger politics: "To reap prestige and financial support (from whatever source), scientists must also demonstrate that their work is ultimately objective and useful to a broad constituency" (p. 1593).

Is there an opportunity for social mobility in STEM? Within STEM discourses, the question is usually answered through citation of various metrics -international test data, graduation numbers, and employment statistics- until generally concluding that good-paying jobs are available for the "approximately two-thirds of our future workforce -women, people of color, and people with disabilities- [currently] minimally tapped as a source of future engineers" (STEM Connector, 2012, p. 125). The pipeline must flow. During recent years, however, a growing body of literature has questioned whether there are STEM job vacancies and, in particular, cites an apparent lack of growth in STEM wages as indicating limited demand (Costa, 2012; Charette, 2013). Brainard (2007) makes a similar observation when explaining the hesitancy of some politicians to institute national quotas for the production of STEM workers and educators:

> Congress declined the call [in Rising Above the Gathering Storm] because lawmakers knew that attempts to project the number of jobs in science and

> engineering have been notoriously inaccurate [...] What's more, wages for scientists and engineers grew no faster than for all workers from 1995 to 2005, according to the Commission on Professionals in Science and Technology --not what you'd expect during a shortage. (p. A22)

Salsman and Lynn (2010), meanwhile, question the validity of such metrics as well as their conventional interpretation in a critique that is impressive for its comprehensiveness: (a) the use of "nation" as unit of analysis is inappropriate; (b) the priorities and tactics of high scoring counties are unsuitable as a model for the United States; (c) test performance does not equate with "competitively desirable outcomes" (d) America has no shortage of STEM experts;[31] (e) the bulk of engineers graduated in China and India are unqualified by international standards; (f) the work of most STEM workers has little to do with "innovation;" (g) most workers in STEM fields are not accredited in a STEM discipline;[32] (h) American test performance and curriculum is actually improving, and, by the way; (i) wouldn't it be nice if instead the educational conversation was about "other educational priorities, including civic engagement, social mobility, and overall development of the national population" (p. 4)?

Whatever the outcomes of esoteric statistical methods employed by STEM advocates or their detractors, there remains another source of discursive resistance. Even if there was an indisputable statistical forecast indicating opportunities for social mobility in STEM, historical metaphors and discursive resources that might yet offer resistance. Here, the so-called "feminization of the teaching profession" during the 20th Century

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[31] Brainard (2007) notes "its educational provisions do not emphasize training more college-educated scientists and engineers. Instead the act pushes better-qualified science teachers in elementary and secondary schools, with the goal of improving the public's scientific literacy. This approach is sensible, experts say, because despite the alarm over growing numbers of engineers being trained in China and India, there is no shortage of college-educated American scientists" (p. A22)

[32] "We found in our earlier STEM reports, many college-educated STEM workers do not have STEM degrees" (US Department of Commerce, 2011b, p. 3).

might be instructive: “As the gender ratios of teachers changed, so did the pay and the social prestige associated with teaching” (Boyle, 2014). If the prejudices of American civilization are fundamental, as Critical Race discourse argues, then even a substantive opportunity for mobility can only coexist with American civilization as a fleeting anomaly.

A report published by the Girl Scouts (2012) found a significant majority of girls surveyed desired a career allowing them to “change the world,” and “help people.” The report further claims that more girls will pursue STEM if they can be persuaded that the STEM pipeline ends in the possibility "to change the way things are done, to improve the environment, to make people healthier, or to make life more efficient” (p. 27). Of course, one imagines that such a line of persuasion would mention nothing of the disappointment graduate students report experiencing in the sciences experience "upon discovering the high levels of entrepreneurialism required to keep a university laboratory afloat [or how] many believed they would have more autonomy and flexibility, experience less pressure in academia, and be better able to serve the public good" (Moore et al., 2011, p. 9). Here, there appears to be a conflict between the values of academic capitalism,[33] which are correspond with STEM completion rationales, and those of the equity the discourses that

[33] Moore uses this term to explain a trend, "asymmetric convergence," whereby universities and industries increasingly resemble one another; however, the convergence is asymmetrical because "industry maintains an economic and (increasingly) cultural advantage” p. 9. In example, Moore reports: "administrators emphasized entrepreneurship and the spread of private-sector practices to university management," they scrutinized more closely "the performance of academic units, often using numerical standards," and inexorably "an 'audit culture' came to permeate the university, in which faculty became objects of managerial discipline and the financial autonomy of departments was undermined." Furthermore, "universities moved away from cultivating administrative leadership within the academy itself and instead increasingly sought with industrial or government management experience." Students began to be understood as "customers" and performance became measured in "customer satisfaction." This is the context for the emergence of the scientist-entrepreneur (Moore et al, 2011, p. 8). See also "the free agent learner" and "free agent teacher" (Project Tomorrow & Blackboard Inc., 2013, p. 4).

claim to represent the interests of girls. Consider, for example, incongruities between the reported interests of girls and opportunities posed by a STEM job market in which the highest paying STEM job are in the oil industry [34] or in which employment depends on sustaining war-time military wherein STEM knowledge is valued as a "force multiplier" (Lewis, 2006).[35] Here, the social equity rationale may be countered by the competition rationale. Rather than offer girls opportunities for social mobility and improved status, STEM occupations offer work that is fundamentally inconsistent with the values of that surveyed girls associated with a good career and, perhaps even, a good life.

[34] Citing developments in the oil industry, Salzman and Lynn (2010) describe increases in demand for "STEM-trained professionals" as misleading insofar as these demands are uniquely affected by dynamics within their specific fields; for example, the combination of rising oil prices and an aging workforce created a demand for engineers to develop new prospecting and extraction projects beginning around 2002; subsequently, the starting salary for an engineer in this field rose from $43,674 in 1997 to $86,220 in 2010. Meanwhile, the starting salary in what was previously the highest-paid engineering profession, chemical engineering, has grown at about half the rate of petroleum engineers (i.e. from $42,817 in 1997 to $65,142 in 2010, p. 13).

[35] The Center for Strategic and International Studies illustrates the rhetoric of militaristic STEM advocacy rhetoric when describing STEM as a force multiplier and recommending "change the U.S. military into a force defined by mobility and swiftness, one that is easier to deploy and sustain, and which relies on stealth, precision weaponry and information technologies for superiority over its opponents" (Lewis, 2006, p. 7). See Footnote 29 for a more detailed discussion of ties between STEM and military employment.

CHAPTER 5

CONCLUSION

The Answer to Everything

My interest throughout this work has been critical and to avoid prescribing any specific program for prosperity or the development of new institutions, initiatives and laws can -in principle- offer us no greater assurance of liberation than those they would replace (Foucault, 1989/1996, p. 339; Sadan, 1997/2004, p. 160). I have struggled to resist advocating of any guiding principles from which an relational alternative to STEM might be developed: i.e. a strategy of neo- anti- re- inter- trans- or extra- "STEM," except to suggest with Foucault that "perhaps one must not be for consensuality, but one must be against nonconsensuality" (Foucault & Rainbow, 1984, p. 379).

Meanwhile, a neutral or apolitical posture is not forthcoming, since the appearance of such a possibility could only be illusory and contingent upon ongoing historical processes. Donna Haraway's (1991) opening qualification, "For political people," is no qualification at all when proceeding, "…social constructionism cannot be allowed to decay into the radiant emanations of cynicism" (p. 184). The inescapable imperative is to believe and to act, even perhaps despite an outlook that "negates any ultimate or transcendent good or value or form from which to argue" (Croissant, 2000, p. 231). This contradiction –the demand for an unlimited system of possibilities- is one that I call the *Problem of Liberation*, and it has generated considerable commentary during recent decades. In the proceeding section, I put two responses to the Problem of Liberation into conversation with my critiques of STEM rationales. My aim, here, is to

develop some ideas for opening the discursive field currently represented as “STEM” to greater discursive possibilities.

As I hope my work has shown, the history of STEM is not inevitably bound to a familiar narrative that centers on an image of Sputnik and is overwhelmingly preoccupied with themes of national and social conflict. Indeed, there is no essential reason why “STEM,” as such, must remain the centering ideograph for so many educators, politicians, and journalists that it has been since 2001. For example, rather than identifying the origins of STEM with Sputnik, less often romanticized events might be chosen such like the establishment of West Point, passage of the Morrill Act, or the inauguration of Stuyvesant High School (to mention only a few options discussed in this text). Similarly, the values emphasized in a redeployed STEM history could be broadened to include not only competition and equity discourses, but also the values of heretofore overlooked stakeholders. It is difficult to predict how the familiar language of *pipelines*, for example, might be transformed if children became recognized as legitimate cultural and political participants in STEM educational discourse. My purpose has not been to advocate any one course of action, but, as Foucault (1989/1996) describes the role of the intellectual, “to re-examine evidence and assumptions, to shake up habitual ways of working and thinking, to dissipate conventional familiarities, to re-evaluate rules and institutions” (p. 462). What follows is my tentative response to the Problem of Liberation, which points toward some ways of doing this. I necessarily joke when calling it “the answer to everything.”

Discursive Mobility

In *Child-Loving*, James Kincaid (1992) proposes what a non-oppositional distinction between *play* and *power*. Acknowledging a debt to Foucault, [36] Kincaid emphasizes play as a liberatory strategy: "I am not proposing a substitute site, just a mode of transportation. I do not believe there is any narrative that can, when naturalized, avoid the horror. But I think the travel between narratives can do wonders for the complexion of things" (p. 385). The "play" he describes, therefore, is concerned with discursive mobility, rather than stable truths. By refusing accountability to a singular system of meaning, exploration becomes possible. The methodological question, as Kincaid (1992) phrases it, appears in deceptively naive terms: "What would it be more fun to say?" (359).

The criticisms against this kind of approach are many and, in some cases, have even been achieved by a simply rephrasing of the proposition in dismissive terms: "there is no escape from power into freedom, for such systems of power are coextensive with human society. We can only step from one to another" (Taylor, 1985, p. 153). White (1978) characterizes such an approach as "absurdist," complaining:

> There is only figuration, hence no privileged position from within language by which language can be called into question. Being, itself, is absurd. Therefore there is no 'meaning,' only the ghostly ballet of alternative 'meanings' which various modes of figuration provide. We are indentured to an endless series of metaphorical translations from one universe of figuratively provided meaning to another. And they are all equally figurative. (p. 281)

[36] Foucault is skeptical of the potential for an altogether radical break from established powers: "there is no escaping from power, that it is always-already present constituting that very thing which one attempts to counter it with" (Foucault & Hurley, 1988, p. 82). Or, in a more famous phrasing that views the situation from the other end: "Where there is power, there is resistance, and yet, or rather consequently, this resistance is never in a position of exteriority in relation to power" (p. 95). The master's tools will never dismantle the master's house, however, barring the option of an effective and perfectly strange approach, it is fortunate that resistance should be inextricable from power.

Mobility might account for a partial definition of freedom, but perhaps not enough if the result is necessarily a universe of strict inconsequentiality. It is in response to this problem, I argue, that several theorists –feminists, in particular– are having the most fun.

Discursive Finitude

"Look at me! / look at me! / look at me now! / it is fun to have fun / but you have to know how." – Dr. Seuss (1957)

In *Situated Knowledge*, Donna Haraway (1988) cautions against an epistemological approach that is commensurate with "allegories of infinite mobility and interchangeability," but rather favors an approach of "elaborate specificity and difference" (p. 583). This recommends a complex discursive field that is comprised of multiple accountabilities to situated and finite truths. Sometimes known as *feminist objectivity* (Haraway, 1988), *feminist empiricism* (Potochic, 2012), *feminist science* (New University Conference, 1970), or *epistemic modernization* (Moore et al., 2011), this approach is neither relativistic nor objectivist, both of which Harraway (1988) has criticized as "god-tricks" that feign "vision from everywhere and nowhere equally and fully" (p. 584). According to this program of feminist objectivity, then, the conventions and institutions that might center empiricism within the truth regime could be reconfigured such that it would no longer be necessary for "the institution of science must present itself as neutral, inevitable, and maintain a balance between autonomy and accessibility to maintain its legitimacy" (Croissant, 2000, p. 230). Indeed, it would become more possible to acknowledge what Moore (1996) characterizes as "the subjective nature of problem choices, methods, and interpretations," "the relationship

between sponsors of science and scientific knowledge," and the ways in which "scientific interpretations and questions interpretations and questions are shaped by patrons and the interests of scientists themselves" (pp. 1594-1613).

Toward a Multiplicity of Mobile and Finite Answers to STEM

About a month ago, a friend of mine who knew I was doing this project e-mailed me a message he had received from The Alliance for Science and Technology Research in America (ASTRA), a non-profit STEM advocacy group comprised of over 130 institutions. The message relates a more-or-less standard telling of the Sputnik narrative in which:

> (1) "The Soviet Union launched Sputnik and electrified the world,"
> (2) Mid-century Americans "saved our country — through science & technology — and moved beyond that to build a space program that lead the world into the future," and
> (3) Federal investment in STEM research is "on track to reach historic lows," so "we cannot wait for another Sputnik moment, we must create our own. (Alliance for Science and Technology Research in America [ASTRA], 2014a)

The purpose of the e-mail is to request a pledge of support for STEM form its audience of listserv subscribers, numbering "close to 45,000 scientists, engineers, entrepreneurs, professors, students, technologists, and others" (ASTRA, 2014b). To date (five weeks after the mailing), the pledge has only inspired the support of 116 signatures (ASTRA, 2014c).

I wonder if this relatively limited show of support indicates dissatisfaction with the present narrative and its politics in relationship to STEM. Although the Sputnik narrative may continue to convey the rationales and interests of certain legislators, educators, and corporations, perhaps its capacity to center beliefs and tell truths may be in

decline. Perhaps now is advantageous time to open the discursive field to a diversity of limited narratives. (It always is).

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