Alphabet Soup: Why Making STEM into STREAM Will Not Fix the Imbalance in Education

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In the last dozen or so years, you can't talk about education without hearing the term "STEM." This acronym, representing "Science," "Technology," "Engineering," and "Math," has become a loaded topic in education. Educators, administrators, and politicians take for granted that these topics should be the main area of focus for K-12 educators. However, in more recent years, there has been substantial disagreement on how necessary and useful—or even detrimental—this focus is. In this paper, I will attempt to define what a STEM worker is, as there is no formal definition of the term. We will look at how science and technology alarmists have convinced educators, lobbyists, and politicians that there is a STEM worker shortage in America, while there is little to no research confirming this shortage. We will also look at the recent addition of "A" and even "R" to the acronym to represent "Arts" and "Reading/wRiting" as an attempt to force other fields into the STEM craze. We will examine why the arts and humanities are essential to us outside of their pure utility in increasing traditional "STEM" scores or writing grammatically-correct reports or research papers. Finally, we will conclude by discussing the perceived dichotomy between STEM fields and the arts/humanities as relating to current neuroscience research examining the tension between empathic and analytic reasoning. Adding "Reading" or "Arts" to STEM will not, in reality, balance the questionable emphasis on analytic reasoning in modern K-12 education and beyond; the arts and humanities need to be recognized for their value in fostering empathic thinking, independent of its counterpart analytic thinking, as an imperative tool to not only develop stronger interpersonal relationships, but also create narratives that can bring countless disparate people together.

To begin with the most basic question: what is a STEM worker? Is it anyone who has a degree in a STEM field? Is it one who currently works in a STEM field, regardless of their degree? And what is a STEM field? According to the National Science Foundation's National Center for Science and Engineering Statistics, occupations covered include: "Computer and mathematical scientists; biological, agricultural, and other life scientists; physical and related scientists; social and related scientists; and engineers" (Finamore, et al., 2013, p. 4), while S&E-"related" [Science and Engineering-related] occupations are a broader category, including "health-related occupations, S&E managers, S&E precollege teachers, S&E technicians and technologists, and other S&E-related occupations, such as architects and actuaries" (Finamore, et al., 2013, p. 4). However, this definition is contested even within the United States government. According to the U.S. Bureau of Labor Statistics, STEM occupations include the following: mathematical science occupations; architects, surveyors, and cartographers; STEM-related postsecondary teachers; physical scientists; life scientists; life and physical science technicians; STEM-related sales; STEM-related management; drafters, engineering technicians, and mapping technicians; engineers; and computer occupations (Fayer, Lacey, & Watson, 2017, p. 2). Some discrepancy is already evident. For example, the NSF considers actuaries S&E-related, while they are not counted in the BLS calculations.

Even more telling is that, according to the BLS, social scientists are counted as STEM occupations, but in the NSF reports there is no mention of them. Social science majors in the US represent a vast share of students; according to a Georgetown University report, it is the third largest grouping of majors, behind only the humanities and liberal arts and engineering (Carnevale, Strohl, and Melton, 2013, p. 37). Then another question regarding education arises: according to a different Georgetown University study, ". . . out of 100 students who obtain a

Bachelor's degree, only 19 will graduate with a STEM major" (Carnevale, Smith, and Melton, 2014, pp. 43). Furthermore, only 10 of those 19 students will work in a job related to their degree in the first years after graduation, and after 10 years, that number drops to eight (Carnevale, Smith, and Melton, 2014, pp. 43). Are those original 19 STEM workers? Or is it just eight? The categorization remains ambiguous and can change from source to source. The National Science Foundation found that "in 2015, estimates of the size of the S&E workforce ranged from over 6 million to more than 23 million depending on the definition used" (National Science Board, 2018, p. 302). Thus merely defining the fields included in STEM is already proving impossible.

As shown above, the term "STEM workers" has become something of a hollow buzzword and is largely open to interpretation. Yet the idea that there is a "shortage" of said STEM workers has pervaded the discussion on education; it has gotten to the point that such assertions are regarded as conventional wisdom. These claims are also nothing new—sources going back as far as a century ago have always warned that we as a country are falling behind in engineering and technology when compared to other countries. An article published by the Institute of Electrical and Electronics Engineers cites at least one quote per decade claiming there is a shortage of engineers going back to the 1930s. In 1934, the dean of NYU's College of Engineering said "one of our greatest industrial organizations, after careful study, predicts the entire absorption of [engineers] by the end of 1936, with a probable shortage of available engineers at that time" (as quoted in Charette, 2013). In 1945, the director of the U.S. Office of Scientific Research and Development claimed that we would "enter the postwar period with a serious deficit in our trained scientific personnel" (as quoted in Charette, 2013). In 1954 it was the president of MIT claiming our national defense was threatened by this shortage; then in 1970 another college president alleged that "the expected demand for engineers will exceed not only the supply coming from American engineering schools, but also the combined supply from the United States and foreign countries"; finally, Bill Gates and the CEO of Texas Instruments echoed these sentiments in 2008 and 2013, respectively (Charette, 2013). In fact, from this timeline it is clear that such claims have been made every decade for the past 90 years.

However, these claims are made in direct contradiction to the evidence: a plethora of studies have found that there is no shortage of STEM workers at all. A study from the RAND Corporation, a nonprofit research organization, "did not find evidence that such shortages have existed at least since 1990, nor that they are on the horizon" (Butz et al., 2004, p. xv). A working paper published by the National Bureau of Economic Research claims, "The job market for young scientists and engineers in the US has worsened relative to job markets for young workers in many other high-level occupations, which discourages US students from going on in these fields" (Freeman, 2005, p. 2). This paper also points out that while every few years or so, high-level tech executives make the claim that the US has a shortage of scientists and engineers, economists have "struggled to interpret these claims" (Freeman, 2005, p. 9). A particularly telling analysis of students in the S&E pipeline, from education to the labor market, found that not only is there no shortage of S&E workers, but the supply of scientists and engineers far outweighs demand: "each year there are more than three times as many S&E four-year college graduates as S&E job openings" (Lowell & Salzman, 2007, p. ii). These and many more sources have found little-to-no evidence suggesting there currently is—or ever has been—a STEM worker crisis in the United States.

After reviewing the data and seeing that there is no shortage of STEM workers, the next logical question is why, then, does everyone seem to think there is one? Michael S. Teitelbaum's 2014 book *Falling Behind?: Boom, Bust, and the Global Race for Scientific Talent* addresses this very question. A research associate at Harvard Law School, Teitelbaum has identified a pattern of "alarm, boom, and bust" dating back to at least World War II in relation to the United States' science and engineering workforce (Teitelbaum, 2014, p. 2). The first stage, "alarm," involves corporate, political, and opinion leaders claiming, without evidence, that the United States is "'falling behind' in the supply of scientists and/or engineers" (Teitelbaum, 2014, pp. 2). Teitelbaum describes the second stage, "boom," as one where U.S. policymakers get involved, resulting in the "rapid expansion in the supply of scientists and engineers" (Teitelbaum, 2014, pp. 2-3). In the final stage, "bust," this influx of young people now educated in the sciences and engineering enter a suddenly tepid job market (Teitelbaum, 2014, pp. 3). This cycle has been repeated by policymakers not just in the United States, but also abroad in countries such as India, South Africa, and Brazil (Charette, 2013). Teitelbaum has found in his research not only that problems with "the U.S. science and engineering workforce are structural in origin and cannot be cured simply by providing additional funding," but also that "efforts of this kind have proved to be destabilizing" and harmful to the workforce (Teitelbaum, 2014, pp. 3). Many of the cycles that Teitelbaum writes about in his book were initiated by national security concerns, such as the cycle that started when Sputnik was launched in 1957, or the one that began in the 1980s with the United States' defense stockpile under Ronald Reagan (Teitelbaum, 2014, pp. 28). These repeated cycles show that United States policymakers, lobbyists, and other political leaders have continuously used "national security concerns" as an excuse to cause panic about the scientist and engineer workforce, resulting in money being poured into these subjects, as will be demonstrated later in this paper, with little examination or questioning by outside parties.

I would argue that it is not a coincidence that these lobbyists and other leaders are increasing funding to subjects that are frequently used to advance military technology. The

United States obviously has a vested interest in maintaining their military, and the STEM "crazes" that they push serve a very specific purpose. A 2011 study by the Department of Defense emphasized that "70% of department employees would be eligible for retirement in the STEM fields by 2013" (Land, 2013, p. 548). The U.S. military, as well as the tech corporations we have seen grow exponentially in recent years, want as big of a pool of scientists and engineers as possible, so that they can hire only the best and the brightest while leaving the others behind. Alan Greenspan, former chairman of the Federal Reserve, said in 2007 that he advocated for "boosting the number of skilled immigrants entering the United States so as to 'suppress' the wages of their U.S. counterparts, which he considered too high" (Charette, 2013). This evidence shows government leaders' explicit intention of flooding the labor market in order to keep wages low.

Once we acknowledge that the "shortage" alarmists have perpetuated is questionable at best, we can examine the addition of more letters ("A"rts and "R"eading/w"R"iting) to the STEM acronym, turning it into STEAM or even STREAM. These attempts began in the 2000s into the early 2010s, with a foundational paper on the subject written by scholar and middle school technology education teacher Georgette Yakman. In her paper "STEAM Education: an overview of creating a model of integrative education," she presents STEAM (stylized ST∑@M) as a model for educators to integrate the "silos" of the traditional subjects into a more comprehensive and cohesive curriculum (Yakman, 2008, p. 1). She discusses the history of major educational theorists, starting with Socrates and Aristotle, through Descartes, Rousseau, Dewey, and many others (Yakman, 2008, pp. 2-4). She particularly emphasizes that Dewey "promotes spelling out linkages between concepts, contents, and contexts to look for connections that are not obvious," claiming that this approach is at the essence of what STEAM education is meant to be (2008, p. 4). She quotes leading technology education scholar W. E. Dugger Jr. as explaining the STEM craze thusly:

> STEM is a politically good move,philosophically, mathematics and science don't want to adopt technology and neither does technology want to adopt mathematics and science. There are pitfalls and opportunities with all of these options. We [technology educators] are moving towards engineering education and STEM versus [engineering] becoming part of science. (as quoted in Yakman, 2008, p. 11)

The first sentence in this quote lays out what one might assume up front but be unwilling to say—it's all about the money. It is very interesting that Yakman included this quote in her paper, as it could somewhat undermine her point. She interprets Dugger's quote as a fear of disciplines "being lost within each other", and presents STEAM as the way to balance the perceived power disparity between disciplines in regards to politics and economics (Yakman, 2008, p. 11). However, I would argue that this framework that she presents is nothing more than a politically convenient way to squeeze the arts into a framework that has nothing to do with them solely to get more funding.

To be sure, Yakman's implicit concerns about politics and funding are extremely valid. As recently as November 2019, the United States federal government announced it has plans to invest $540 million in STEM fields, with almost 20% of that going to projects specifically focusing on computer science (U.S. Department of Education, 2019, paras. 1, 6). The executive branch's proposed budget last year suggested eliminating four federal agencies: the National Endowment for the Arts, the National Endowment for the Humanities, the Institute of Museum and Library Services and the Corporation for Public Broadcasting. The budget cut between the four of them amounts to almost $1 billion (McGlone, 2018, paras. 1-2). This proposal is nothing new, and the leaders of these organizations have emphasized that such budget cuts will completely decimate these organizations (McGlone, 2018, paras. 5, 8, 11-16). Federal funding of the arts and humanities through national endowments for each of them has always been dwarfed by federal funding of science and engineering research, but in recent years that gap has been growing (American Academy of Arts and Sciences, 2013, p. 39). In 2011, the federal government provided more than twice the amount of academic research and development funding to the biological sciences, engineering, mathematical & physical sciences, and medical sciences than it did to the humanities (American Academy of Arts and Sciences, 2013, p. 42). The federal funding gap places a quantified value on certain majors or areas of study over others and creates a rift in the perceived value of these areas of study. This perceived value then influences federal budgets, and the cycle continues.

Some leaders in the arts and humanities try to combat this funding gap with arguments about why the arts are important in relation to the economy or even in relation to science and math scores. For example, when the federal budget proposed cutting four arts and humanities endowments, Robert Lynch, president and CEO of Americans for the Arts, pushed back by saying that “all the data, everything, points to the fact that investment in the arts industry has been a big win, economically and job-wise” (as quoted in McGlone, 2018, para. 5). Studies have found that verbal and math SAT scores of students who study any form of art in high school are significantly higher than those who don’t (Vaughn & Winner, 2000, p. 86). This common argument is based on the axiom that the arts are only useful in relation to scientific subjects or to the job market. However, nowhere do policymakers address the importance of the arts in and of itself, let alone the utility of science and engineering in relation to advancing studies in the arts and humanities.

Since there is a push to move funding away from the arts and into science and engineering, it would make sense that educators and researchers in those fields are desperate to retain funding in any way possible. Their newest approach is adding "A" and even "R" to the acronym to represent "Arts" and "Reading/wRiting." However, the idea of adding these disciplines to "STEM" is extremely misguided. In another foundational paper on STEAM, art educator Michelle Land makes a transparent argument that is completely damning. She writes:

> Moreover, the "Annual Industrial Capabilities Report to Congress", from the Department of Defense in 2011, estimated that 70% of department employees would be eligible for retirement in the STEM fields by 2013. With a hasty youth focused on self-indulgence and leisure, we must make STEM education more appealing. Adding the arts into the STEM equation can re-invigorate the platform, providing not only an interesting approach, but also opportunities for the self-expression and personal connection new generations crave. (Land, 2013, p. 548)

This quote is particularly incriminatory for several reasons. For one, by specifically citing the Department of Defense as a reason to attract more young people to STEM fields, she proves that the push to get more students into STEM is a not-so-thinly veiled attempt by the U.S. government to drive U.S. superiority in science and engineering for purposes of war, a pattern we have seen before from alarmists in times of supposed national security concern. If the reason we need students to study science and engineering is just because we need the Department of Defense to be fully staffed, then what more is this craze than another one of the alarm/boom/bust cycles that Teitelbaum identified in his book? It is just another repetition of history that has already been repeated so many times in the last century. The second part of this quote that is damning to her point is that she explicitly states that adding arts to STEM is simply a marketing ploy. Nowhere is the actual value of the arts discussed; it's simply added as a way to appeal to what older generations see as lazy kids. There is no attempt to integrate the arts in an actually meaningful or valuable way. The above quote sums up the academic attitude toward STEAM; none of the papers I have found attempt to talk about why the arts are valuable *outside* of the context of science or the economy. The focus is always on a return on investment, whether for individuals who choose to study the arts or for the military-industrial complex. The benefits that they provide in terms of health, happiness, and quality of life for people living in society are not considered.

The arts and humanities have the unique ability to look at things in context and in relation to past events. Science cannot look at subjects in context. The scientific method necessitates that all observations are made separately, in a sterile and reproducible environment. Without context though, the observations are meaningless. Without using the arts and humanities to contextualize and interpret claims made by science, what's the point of making any scientific claims? In her 1985 essay "Poetry is Not a Luxury," Audre Lorde lays out the titular argument: "Poetry is the way we help give name to the nameless so it can be thought" (p. 372). She continues: "…there are no new ideas. There are only new ways of making them felt —of examining what those ideas feel like…" (Lorde, 1985, p. 373). This is the unique value that the arts and humanities have that the sciences could never supply. Poems such as Homer's *Iliad* and *Odyssey* connect us with the past, as some of the only remnants of cultures that have died off long ago. Ancient plays tell us about the lives of people who lived thousands of years before us, and the fact that they survived and are still performed today connects us to the past in a way science never could. Without the arts, we would not be able to, as Lorde says, "give name to the nameless." No form of science can name what love is, or what friendship means, or how grief feels, and these are precisely the thoughts that make life worth living at all. For this reason, the discourse on this issue is backwards. The sciences are not fundamental while the arts are secondary, as the current discussion assumes; in fact, without the arts and humanities, science is utterly meaningless and useless.

Psychiatrist Iain McGilchrist makes an argument similar to the above in his book *The Master and his Emissary*. He focuses on the right and left hemispheres of the brain, explaining the difference in world views these two hemispheres represent. According to him, the right hemisphere processes information in a holistic way, while the left is detail-focused (McGilchrist, 2010, p. 51-52). While the neuroscience of "left" and "right" brained personalities has largely been debunked (Shmerling, 2019, paras. 10, 12), the most current work in neuroscience uses recent advances in neuroimaging technology to show that there is a comparable distinction between brain networks for higher cognition. These separate neural networks control task-oriented, or analytic, thinking versus socio-emotional, or empathic, thinking, and there is evidence that use of one network suppresses the other (Boyatzis, Rochford, & Jack, 2014, p. 1). McGilchrist's assertion that in recent years the "left" mode of thinking, or more accurately the analytic neural network, has been given undue primacy over the "right," or empathic neural network (p. 6-7), draws a direct parallel to what was discussed above in relation to education. As previously stated, only arts and humanities have the ability to look at things holistically, aligning with the world view of empathic thinking. The analytic mode of thinking takes details and looks at them in isolation, stripped of their context, much as science and engineering inherently must do. The analogy continues with the emphasis on the analytic neural network, which in this analogy is represented by STEM fields. This imbalance favoring the analytic side of our brains is not only undeserved but actively detrimental to society. As McGilchrist argues, all experiences begin and end with an empathic world view (p. 6). Similarly, all scientific research begins and ends in a human context, whose social, emotional, and embodied aspects can only be fully understood through empathic reason; i.e., through the lens of the arts and humanities. Without context, our experiences are meaningless. Without context, science is meaningless.

As I hope I have shown above, the arts and humanities allow us to create meaning from and give context to our experiences—one aspect of which might be scientific discoveries. Similar to the relationship between analytic and empathic modes of thinking, as McGilchrist defines them, all experiences must begin and end with the context given to us by the arts. In the area of education specifically, this order has been turned upside down, with undue emphasis being given to STEM fields in the form of monetary funding and perceived value. This STEM prominence has come to exist because of a cycle of "alarm/boom/bust" perpetuated by political leaders and lobbyists with the interest of maintaining U.S. superiority in times of perceived national security crises. However, these cycles have actually been shown to flood the scientist and engineer labor force so that military and technology leaders can have their pick of the brightest employees, leaving a surplus of workers and a "bust" phase for the market. Because of this STEM focus, researchers and educators in the arts and humanities have tried to market the arts as useful to scientists in very superficial ways. This is a strategy to retain funding by proving themselves useful to the primary subject areas of science and engineering. However, this approach is misguided. The arts and humanities must be recognized for their value in and of themselves. The "primacy" of certain subjects needs to be reassessed. Discoveries in science and engineering begin and end with discoveries about our humanity that must be addressed using the unique tools provided to us by the arts. In the short term, fighting for funding for the arts and humanities is undeniably essential. In the long term, we must strive to change the conversation around why the arts must be funded and supported equally by the government, the public, and the education system as a whole.

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