

Myths and Motives behind STEM
(Science, Technology, Engineering, and Mathematics)
Education and the STEM-Worker Shortage Narrative

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We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time.

—T.S. Eliot, *Four Quartets*

The Business Roundtable (2013) website presents a common narrative in regard to STEM (Science, Technology, Engineering and Mathematics) education,

American students are falling behind in math and science. Fewer and fewer students are pursuing careers in science, technology, engineering and mathematics, and American students are performing at levels far below students in competitor nations on international standardized tests in these subjects. (para.3)

This message is echoed in numerous federal reports (e.g., NAP, 2005; 2010; PCAST, 2010:2012) and statements concerning STEM education from the United States' (U.S.) President Barack Obama. An example of such an announcement from Obama includes,

Reaffirming and strengthening America's role as the world's engine of

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scientific discovery and technological innovation is essential to meeting the challenges of this century. That's why I am committed to making the improvement of STEM education over the next decade a national priority. (White House, 2009, para. 4)

In order to bolster the United States' performance in the global economy, and address the scarcity of U.S. STEM-qualified graduates, the business and nonprofit community have partnered to improve STEM education. To this end, they have formed at least three organizations: (1) STEMConnector provides profiles of more than 5000 stakeholders to map STEM education across states under categories such as business, government, associations diversity, and women and education (STEM-Connector, 2013), (2) TAP (Tapping America's Potential) consists of 15 major business associations such as the Business Roundtable and U.S. Chamber of Commerce with a goal of increasing the annual number of STEM bachelor's-level graduates to 400,000 (Tapcoalition, 2013), and (3) 100kin10, includes over 26 funders pledging over \$52 million toward their work with over 121 partners who make commitments to train 100,000 STEM teachers by 2021 (100kin10, 2013). 100kin10 offers to raise funds and challenges the U.S. Congress "to fund the rest" (100kin10, 2013; The White House, 2009).

Obama supports such initiatives as evidenced by his 2013 State of the Union Address, which calls for the training of 100,000 STEM teachers (The White House, 2013). In addition, Obama recognizes the importance of training STEM workers by stating,

We'll reward schools that develop new partnerships with colleges and employers, and create classes that focus on science, technology, engineering, and math—the skills today's employers are looking for to fill jobs right now and in the future. (para. 42)

The narrative posed by the Business Roundtable of a failing U.S. education system and STEM-worker shortage seems to be confirmed by businesses, nonprofits and the Obama administration, as they show their monetary and organizational support to remedy this purported STEM crisis. What if instead of a U.S. STEM-worker shortage, there is a STEM-worker surplus? Then the questions become: (1) What are the advantages of stating there is a STEM-worker shortage if there is none? and (2) Who benefits from perpetuating a manufactured STEM-worker shortage? Before critically analyzing answers to these questions, the STEM-worker shortage narrative will be put into context by exploring its development.

The History of the STEM-Worker Shortage Narrative

The historical sense involves a perception, not only of the pastness of the past, but of its presence.

—T.S. Eliot, *Four Quartets*

Gonzalez and Kunezi (2012) claim the significant impact of science on the prosperity of the United States was recognized as early as the first Congress. In the first State of the Union Address, George Washington (1790) promoted scientific knowledge for the wellbeing of the nation by pronouncing,

Nor am I less persuaded that you will agree with me in opinion that there is nothing which can better deserve your patronage than the promotion of science and literature. Knowledge is in every country the surest basis of public happiness. In one in which the measures of government receive their impressions so immediately from the sense of the community as in ours it is proportionably [sic] essential. (p. 1)

Since this time, there has been a transformation in the U.S. in which financial prosperity and homeland safety, not knowledge, are perceived as paramount in safeguarding “public happiness.”

The modern STEM crisis can be traced to the 1950s when there was a perceived threat to U.S. economic and homeland security by the launch of Sputnik, and fear that the Soviet Union was annually producing almost twice as many more scientists and engineers than the United States. Teitelbaum (in Charette, 2013) maintains that since that time there has been a cycle of alarm, boom and bust.

He [Teitelbaum] says the cycle usually starts when ‘someone or some group sounds the alarm that there is a critical crisis of insufficient numbers of scientists, engineers, and mathematicians’ and as a result the country ‘is in jeopardy of either national security risk or falling behind economically. (In Charette, 2013, “So why the persistent,” para. 1)

This cycle continues to repeat throughout the ongoing development of the STEM-worker shortage narrative.

The Natural Sciences Narrative of the 1980s

The crafting of a deliberately misleading message regarding the STEM-worker shortage began during the mid 1980s. At this time, the National Science Foundation (NSF) conducted a deceptively simple demographically -based study projecting that, due to the fact that the number of 22-year olds participating in natural sciences and engineering was decreasing, there would be a shortfall of employees in these areas (Berliner & Biddle, 1995; Wolpe, 1992). This study was never published,

but served as a widely circulated and influential paper (Greenberg, 1991), that allegedly impacted the Immigration Act of 1990, and was later deemed erroneous by NSF director Neal Lane in his Congressional Testimony on July 13, 1995.

Natural sciences salaries in the U.S. What appears to have happened prior to the release of the demographically -based paper referenced above is that the Policy Research Analysis Division (PRA) of the NSF performed a market analysis of the natural sciences industry which predicted a dramatic rise in salaries. The report stated,

These salary data show that real PhD-level pay began to rise after 1982, moving from \$52,000 to \$64,000 in 1987 (measured in 1984 dollars). One set of salary projections shows that real pay will reach \$75,000 in 1996 and approach \$100,000 shortly beyond the year 2000. (PRA, via Weinstein, 1998, p. 14)

This significant and rapid increase in salaries was of great concern to employers of natural scientists, and they began to look for a strategy to counter this inevitable trend.

The role of foreign workers in ensuring low salaries in natural sciences. The PRA market analysis indicates that despite external calls for additional U.S. students to enter scientific careers, the NSF was actually concerned about enticing too many U.S. students (Weinstien, 1998). The analysis states, “[To] the extent that increases in foreign student enrollments in doctoral programs decline or turn negative for reasons other than state or national policies it may be in the national interest to actively encourage foreign students.” It goes on to say, “A growing influx of foreign Ph.D.’s into U.S. labor markets will hold down the level of Ph.D salaries” (PRA, in Weinstein, 1998, p. 14). It becomes apparent that crafting a natural sciences shortage narrative affords businesses with a rationale for both hiring foreign workers and requesting to raise the number of H-1B visas issued, in order to ensure lower company expenditures on salaries.

Armed with these data on unavoidable salary increases and the utility of foreign students to provide cheaper labor and saturate the job market, directors of the NSF (Erich Bloch) and PRA (Peter House) at the time, allegedly suppressed data from statisticians that refuted the worker shortage narrative (Weinstein, 1998). Aggressive nationalistic appeals were issued in regard to the natural sciences worker shortage in an effort to support the passage of the Immigration Act of 1990, which increased the number of visas for immigrant employment (e.g., Wall Street Journal, 1990; Wattenberg, 1990). The tacit intention was

to increase foreign employment in the U.S. natural sciences, thereby interrupting the free market's current upward trajectory of salaries (Weinstein, 1998).

The Technology Bubble of 2001

In the late 1990s Information Technology (IT) firms began lobbying in Washington, D.C. repeating the message that there is an IT worker shortage. Reports of dubious data on vacant IT positions were issued, and available H-1B visas tripled beginning in 2001 (Teitelbaum, 2007). It is of importance to note that H-1B visas are used for either employing foreign workers in the U.S., or as a medium for outsourcing positions to other countries. Is it a coincidence that the U.S. technology bust began in 2001?

The STEM Shortage Narrative in the Mid-2000s

On October 20, 2005, Norman Augustine, as Chair of the Committee on Prospering in the Global Economy of the 21st Century and the Committee on Science, Engineering, and Public Policy Division on Policy and Global Affairs, testified before the U.S. House of Representatives to relay his committees' four recommended action steps to ensure that the US remains globally competitive: (1) *Ten Thousand Teachers and 10 Million Minds*, which is concerned with training inservice and recruiting and educating preservice teachers, (2) *Sowing the Seeds* which represents increasing investments in research, (3) *The Best and Brightest*, which considers higher education in recruiting more US and foreign students and granting visas to secure employment for foreign graduates and (4) *Incentives for Innovation*, which address supporting legislation and tax credits to support innovation (Augustine, 2005).

This congressional testimony of Augustine (2005) and the related report *Rising Above the Gathering Storm* (NAP, 2005) is recognized as being highly influential in the development of the existing STEM-qualified worker shortage narrative (e.g., Benderly, 2012; Cherette, 2013; Gonzalez & Kunezi, 2012). With respect to why the report's argument is so influential, Teitelbaum (in Benderly, 2007) says, "...because it is a point of view held and put forward strongly by very visible and reputable people and organizations." Augustine's committee members are leaders from research-intensive corporations, laboratories and universities, including Nobel Laureate Joshua Lederberg ("Largely inconsistent with facts," para. 4).

A second report released in 2010, *Rising Above the Gathering Storm Revisited*, (NAP, 2010), increases the urgency by claiming the U.S. economy is continuing to decline since the recommendations in the

2005 report have not been addressed in their entirety. These reports are also influential in the passage of the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act (also known as the America COMPETES Act), which authorizes much of the STEM education funding (Gonzalez & Kunezi, 2012).

The STEM Shortage Narrative Today

The message presented in *The Rising Above the Gathering Storm* reports (NAP, 2005, 2010) continues with the COMPETES Act's reauthorization in 2010 (P.L. 111-358), and with the expiration and possible reauthorization of COMPETES in 2013. Furthermore, recent industry reports (e.g., Atkinson & Stewart, 2013; Rothwell & Ruiz, 2013), publications (e.g., ITIC, 2013; Ozimek, 2013; Wright, 2013) and communications from U.S. President Barack Obama (e.g., Rotherham, 2011) continue to support the STEM-qualified worker shortage. In addition, the Immigration Act of 2013 is seeking to increase the number of H-1B visas available to employers (Benderly, 2012).

STEM Share of Job Market

Part of the confusion regarding today's STEM-qualified worker shortage narrative is that there is not one acceptable standard as to what constitutes a STEM job. For instance, the NSF and Department of Commerce use quite different metrics. The Commerce cites 7.6 million STEM positions in 2010 (5.55% of the population), in contrast the NSF counts 12.4 million STEM jobs, including areas that the Commerce excludes, such as health-care workers (4.3 million) and psychologists and social scientists (518,000) (Charette, 2013). Rothwell (2013) argues that the counting of STEM jobs should include those that not only require a STEM bachelor's degree, but also any position that requires specialized STEM knowledge (e.g., plumbers, car mechanics). One questions how to truly make this determination. Under Rothwell's (2013) classification there are 26 million STEM jobs in the U.S. (or 20%) as opposed to the most commonly held count of 4.4-5% of the population (NAP, 2010). Augustine and his committee (NAP, 2005; 2010) acknowledge the 4% STEM job market statistic, and strongly believe that this small percentage of employees significantly impacts the remaining 96% of positions (NAP, 2010).

The Persistence of the STEM-Worker Shortage Narrative

The publication of a recent report by Salzman, Lowell, and Kuehn (2013) entitled *Guestworkers in the High-Skill U.S. Labor Market: An Analysis of Supply, Employment, and Wage Trends* refutes the STEM-

worker shortage and was followed by a number of pieces reiterating these findings (e.g., North, 2013; Shalin, 2013; Yang, 2013). As mentioned earlier, the creation of the STEM-worker shortage narrative has been continuously tracked by efforts to deny the shortage. Why, then, has the STEM-worker shortage prevailed as the dominant message? Is it because certain individuals believe that the U.S. must always be concerned about the supply of innovative STEM-workers regardless of a demand for their employment? Is there a suspicion that there can never be enough STEM-workers as who knows which one person could make a discovery or invent an item (e.g., like the personal computer, vaccine, medication) that could “save” the U.S. economy?

Teitelbaum (in Benderly, 2007) proposes that the shortage narrative is dominant not only because “people who say other than this are relatively less well-organized” (in Benderly, 2007, Largely inconsistent facts, para. 4), or that the narrative is endorsed by respectable people and organizations. The shortage narrative persists primarily because these highly regarded spokespeople, “believe what they say, and they say it strongly and with conviction” (Teitelbaum in Benderly, 2007, Largely inconsistent facts, para. 4). It is therefore relevant to consider what benefits are received, and by whom, from continuing to promote the STEM-worker shortage narrative.

Deconstructing the Dominant STEM-Worker Shortage Narrative

Humankind cannot bear very much reality.

—T.S. Eliot, *Four Quartets*

What leading STEM labor experts have indicated over a significant span of time, is not only that STEM constitutes only 4-5.5% of the U.S. employment market, but that there is indeed a surplus, not shortage, of STEM-qualified workers (e.g., Bhagwati & Rao, 1996; Costa, 2012; Matloff, 2006; Stephan, 2012). More recently, Salzman et al. (2013) found, “For every two students that U.S. colleges graduate with STEM degrees, only one is hired in a STEM job,” (p. 2). Science and Engineering Indicators (2008), which is the National Science’s Board’s authoritative publication, reports that the U.S. grants three times as many STEM degrees as the economy can accommodate into their job-related majors. Yet, since the mid 1980s the STEM shortage narrative has prevailed, and the Immigration Act of 2013 seeks to increase the number of H-1B visas available to employers (Benderly, 2012).

H-1B Visas

Due to the fact that H-1B visa recipients are allowed to stay in the

U.S. only if they continue to work in the job for which they were hired, they have been referred to as indentured servants that are generally paid in the bottom quartile of salaries for their field (Costa, 2012; Eisenbrey, 2013; Matloff in Harkinson, 2013; Salzman, et al., 2013). H-1B visas can also be used by American corporations to outsource jobs to countries where they can pay much lower salaries to workers engaged in the same employment as higher paid employees working in the U.S. The resulting surplus of low-paid H-1B STEM employees is highly problematic as it deters native-born applicants from entering the field, and it keeps salaries stagnant for existing employees (Matloff, 2013).

Salaries

A rise in salaries across STEM fields is the best indicator of a shortage, but salaries in IT positions (which make up the largest percentage of STEM jobs) have stayed fairly flat with real wages remaining around late 1990s levels (Salzman, et al., 2013). Costa (2012) found that,

...from 2000 to 2011, the average hourly wage for workers possessing at least a bachelor's degree in computer and math occupations rose less than half a percent per year, compared with the sharp wage increases we would see if a labor shortage existed in these occupations. (p. 2)

Engineers and engineer technicians have experienced the least salary growth of all STEM fields. Furthermore, gaining a doctoral degree in science, math or engineering does not provide competitive salaries due to the saturated STEM job market (Salzman et al., 2013).

George Borjas, a Harvard economist, contends that even raising the supply of workers by 10% can result in a decrease of pay by 3-4% (2006). The legal loopholes afforded by H-1B visa positions' lower salaries in a variety of fields and obviously result in significant savings for big businesses (Matloff, 2013). Vivek Wadhwa, an active advocate for expanding foreign worker programs states,

I know from my experience as a tech CEO that H-1Bs are cheaper than domestic hires. Technically, these workers are supposed to be paid a 'prevailing wage,' but this mechanism is riddled with loopholes. (Wadhwa, 2008, para. 28)

Mr. Wadhwa illustrates that even though there are laws to ensure that foreign workers receive salaries commensurate with their native-born counterparts, corporations can easily manipulate laws to ensure low salaries for employees hired on H-1B visas, which results in their "indentured servant" status and lowers salaries for all employees in that industry.

Technology Positions in STEM Employment Market

Information Technology (IT) positions make up the largest portion of STEM jobs, with annual inflows of foreign workers (also known as guest workers) amounting to one-third to one-half the number of all new IT job holders (Salzman, et al., 2013). Sixty-eight percent of IT employees do not have a computer-related degree and 31 percent do not have a STEM degree (Costa, 2012). In fact, only one third of IT positions require a degree (Salzman, et al., 2013).

The STEM Shortage Narrative and Education

Even though there is a surplus of STEM-qualified workers, the shortage narrative appears to endure so that businesses have a viable reason to call for a significant increase in the number of H-1B visas issued annually. Employees hired on H-1B visas are generally paid at lower rates than their comparably skilled U.S. counterparts. This knowledge would seem to exonerate the U.S. educational system from the accusation of failing to provide sufficient numbers of STEM-qualified graduates, since there is actually a surplus of STEM workers. There is little evidence in the literature, however, that this connection has been made.

STEM Education in the Context of the STEM-Worker Shortage Narrative

For last year's words belong to last year's language
And next year's words await another voice.

—T.S. Eliot, *Four Quartets*

With a surplus of U.S. STEM-workers, not a shortage, is the rationale for promoting STEM education negated? Even if much of the STEM-worker hype can be tied to the inflated importance of innovation, and even more so to the business savings achieved through hiring cheaper H-1B visa employees, the development of STEM literacy persists as a worthy aspiration. STEM literacy is the ability to understand and apply STEM concepts to problem solving, and is an indispensable skill for future success (Youth For Youth, 2013). STEM literacy should be coupled with encouraging a life-long love of learning through the wonders that constitute STEM. And, knowing there is a surplus of STEM-workers can hopefully put a damper on calls such as those issued by Florida Governor Rick Scott to focus greater educational funding on STEM education and less on liberal arts (Tabarrok, 2012). Liberal arts are also important as they make for well-rounded and informed citizens who can more readily and capably participate in a democracy (Dewey, 1916; Hurley, 2013).

Seeking Funding

Knowing there is a STEM-worker surplus, should educators discontinue seeking capital through STEM grants and corporate sponsorship? Teachers and teacher educators should pursue STEM funding to create programs that excite students and draw them into the wonders of STEM while supporting STEM literacy. To increase their relevance to students' lives, these programs should be developed with an understanding of the myths and motives behind STEM education and the manufactured STEM-worker shortage.

STEM Careers

Much is heard about the STEM pipeline (e.g., Metcalf, 2010; Franco, Patel & Lindsey, 2012; William & William, 2013) and the push to increase the number of minorities and women who enter STEM fields. Knowing the alarm, boom and bust cycle that Tietelbaum refers to earlier (in Charette, 2013), and the difficulties of gaining employment in STEM, particularly during the boom cycle, educators should be proceeding cautiously, or refraining completely, from "selling" STEM careers. Yes, students should be informed regarding STEM occupations, but they should also be exposed to professions that constitute the remaining 94.5-96% of the U.S. employment market. Pupils who are fervently interested in pursuing STEM employment should surely be supported in doing so, although not for the sake of pushing them through the "backed up" STEM pipeline, but for their sheer passion for one or all STEM content areas.

STEM Education and Profits

As illustrated throughout this article, the U.S. public education system is presented as failing to educate students in STEM. Obama calls on others to "save" STEM education with a tacit understanding that the country's economic stability relies on this rescue mission, by stating,

...while federal leadership is necessary, a real change in STEM education requires the participation of many elements of society, including governors, philanthropists, scientists, engineers, educators, and the private sector. (The White House, 2009, para. 11)

This call has been answered by many organizations (STEMConnector, TAP, 100kin10) and foundations (e.g., Bill and Melinda Gates Foundation, Eli and Edythe Broad Foundation). Venture capitalists have also responded to Obama's invitation and are investing 80% more in education than in 2005 (Rich, 2013). Are these STEM education-aiding entities' motives purely altruistic or profit-driven? It will be interesting to observe the operationalization, and effectiveness of STEM K-12 and teacher

education, as corporations and nonprofits further pervade them with an obligation to stockholders and funders to raise profits, but without the equivalent requirement to increase student learning.

Another significant question that arises is, knowing there is a surplus of STEM-workers, is the U.S. public school system actually failing to train students in STEM? In other words, are interventions in STEM education warranted if there is a surplus of U.S. STEM-qualified workers? If these interventions are not justified as restorative measures, then what is their utility? This leads one to ask, are these initiatives to “rescue” STEM education serving as an entrée for corporations and nonprofits into profiting from one of the last public goods, K-12 public education? The author will address this topic in future publications, and calls on others to research STEM in the context of corporatization of education, so that students’ needs, not the financial bottom line, remain paramount in K-12 and teacher education.

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