The Landscape of STEM Education and Workforce

A White Paper produced by the West Tennessee STEM Hub

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Introduction

The role of STEM education and promotion has long been a topic of discussion in the United States when considering the country's global position, technological progression, and national security. As stated by the White House:

> *The health and longevity of our Nation's citizenry, economy and environmental resources depend in large part on the acceleration of scientific and technological innovations, such as those that improve health care, inspire new industries, protect the environment, and safeguard us from harm. Maintaining America's historical preeminence in the STEM fields will require a concerted and inclusive effort to ensure that the STEM workforce is equipped with the skills and training needed to excel in these fields. [1]*

The importance of STEM is undeniable, and this paper explores the current state of these disciplines in the United States, Tennessee, and West Tennessee. Data regarding the output of STEM graduates and demand in the form of STEM jobs varies drastically among a number sources, especially due to discrepancies related to the jobs and degrees that actually fall under the umbrella of STEM. Consequently, a debate is has developed over whether there is a shortage in STEM workers/graduates or a shortage in STEM jobs. At the same time, diversity in STEM continues to be a recognized issue. While the diversity of the US population is not proportionally represented in STEM education or in the workforce, it is also apparent that educational inequality continues to be a barrier for the academic success of many students.

No matter what the outcome of the STEM deficit debate, the need for qualified and skilled professionals in STEM fields will never diminish. In a 2012 report by the Georgetown Center on Education and the Workforce, it was reported that at least 45 million jobs will require STEM competencies and that 92% of STEM jobs will require some postsecondary education and training by 2018 [2]. In the first decade of the 21st century, STEM jobs grew three times faster than non-STEM job growth [1]. The amount of engineering knowledge and scientific discovery we possess is said to double every decade. Across the US, however, only 4% of college graduates are earning degrees in engineering. Even military academies that strongly advocate engineering are seeing the same numbers in their institutions [3]. As technology and science advances surge, so does the necessity of skilled, well-educated STEM professionals [4].

Other incentives for STEM education exist as well. Most parents favor the prospect of STEM degrees and career paths for their children, as they believe such careers will provide job-security [5]. In Tennessee, for example, one job exists for every 4.3 unemployed jobseekers; in STEM however, 2.1 jobs exist for every one unemployed person with a STEM degree [6].

Defining the STEM Population

In a survey issued by the Tennessee STEM Innovation Network (TSIN), over 50 stakeholders were questioned regarding their perceptions of STEM. When asked to define STEM, the most popular responses included:

- *Project based*
- *Integrated*
- *Multi-disciplinary*
- *For all students*
- *Grounded in "real world concepts"*
- *Partnership to education involving K-12, higher education and business and industry*
- *Just science technology, engineering, and mathematics [7].*

While the basic definition of STEM as science, technology, engineering and math is straightforward enough, other facets of STEM exist in the medical, social science, and management fields. Various groups define STEM differently: the Department of Commerce includes "professional and technical support occupations in the fields of computer science and mathematics, engineering, and life and physical sciences as well as management," while the National Science Foundation includes health-care workers, psychologists, and social scientists in its definition [8]. A recent report released by Brookings [9] has expanded the definition of STEM even more to include:

> *… manufacturing, health care, or construction industries. Installation, maintenance, and repair occupations constitute 12% of all STEM jobs, one of the largest occupational categories. Other blue-collar or technical jobs in fields such as construction and production also frequently demand STEM knowledge.*

According to the Brookings report, blue-collar or nonprofessional jobs rated as 'high-STEM' may include:

- *Installation, maintenance, and repair,*
- *Construction*
- *Production,*
- *Protective services,*
- *Transportation,*
- *Farming, forestry and fishing,*
- *Building and grounds cleaning and maintenance,*
- *Healthcare support*
- *Personal care, and*
- *Food preparation* [9].

For many years, the portion of STEM workers with at least a bachelor's degree have been in the spotlight during conversations about STEM graduate deficits, higher salaries for STEM graduates, and the necessity for a larger STEM workforce to fuel the US economy and collective intelligence [9]. The Praxis Strategy Group (collaborators with the US Chamber of Congress) include the following categories:

- Computer specialists
- Mathematical science occupations
- Engineers
- Drafters, engineering, and mapping technicians
- Life scientists
- Physical scientists
- Social scientists and related occupations
- Life, physical, and social science technicians [10].

This group included the technical positions that only require a two-year degree [10]. This definition enforces the notion that an entire other population of STEM workers exists and is becoming more recognized today: those with a high school degree or two-year associates degree that enter more technical roles, but also play a crucial role in the productivity and sustainability of the US economy.

<u>Challenges for the Advancement of STEM</u>

The Supply and Demand of STEM Skills in the US and Tennessee

In discussions of the supply and demand of STEM educated students, an issue arises as to whether or not a shortage of workers or a shortage of jobs exists. While some argue that a severe shortage of skilled STEM graduates exists, others maintain that there are more people in the STEM workforce than there are jobs to fill.

The number of STEM graduates seems to be less than it has been in past years. An example is found in engineering, as less than 60,000 engineering degrees were awarded per year in the US between 1999 and 2001. Even though the amount did steadily increase to over 65,000 engineering degrees in 2006, the maximum number occurred over twenty years ago; approximately 78,000 engineering bachelor’s degrees were awarded in the US in 1985 [5]. A different source has reported a growth to 83,000 engineering bachelor’s degrees awarded in the US in 2011 [11]. Some predict an increase in the US engineering workforce of 13% between 2004 and 2014. Many complicating factors, however, are included in this prediction (for example, the number of students immigrating to the US to study or perform skilled jobs) [5]. A number of the organizations providing projections like these admit to difficulty in producing accurate projections of growth [8]. Due to complicating factors and conflicting reports, it is difficult to understand where a deficit exists, if anywhere. The following table attempts to clarify this conflict by identifying the number of STEM workers (or graduates) and the number of STEM jobs available for the portions with [1] a bachelor’s degree or more or [2] an associate’s degree or high school education.

TABLE 1 Stratified Supply and Demand for Pre- and Post-Bachelor’s STEM Jobs

<table>
<tr><th colspan="2">Year</th><th colspan="2">United States</th><th colspan="2">Tennessee</th><th>Memphis, TN</th></tr>
<tr><td rowspan="5">STEM Workers</td><td rowspan="2">Associates or less</td><td colspan="2">2010</td><td colspan="2">2012-2013</td><td></td></tr>
<tr><td colspan="2">2.5 Million</td><td colspan="2">15,452 Graduates</td><td></td></tr>
<tr><td rowspan="2">Bachelor’s or more</td><td colspan="2">2010</td><td colspan="2">2012-2013</td><td></td></tr>
<tr><td colspan="2">5.1 Million</td><td colspan="2">39,426 Graduates</td><td></td></tr>
<tr><td>TOTAL</td><td colspan="2">7.6 Million Workers [12]</td><td colspan="2">54,878 Graduates [13]</td><td></td></tr>
<tr><td rowspan="5">STEM Jobs</td><td rowspan="2">Associates or less</td><td>2011</td><td rowspan="2">2018 Projection of Jobs Need</td><td></td><td rowspan="2">2018 Projection of Jobs Need</td><td>2011</td></tr>
<tr><td>13 Million [9]</td><td></td><td>54,844 [3]</td></tr>
<tr><td rowspan="2">Bachelor’s or more</td><td>2011</td><td rowspan="2">8,654,000 [14]</td><td></td><td rowspan="2">109,000 [14]</td><td>2011</td></tr>
<tr><td>26 Million [9]</td><td></td><td>38,746 [9]</td></tr>
<tr><td>TOTAL</td><td>39 Million Jobs</td><td>8,654,000 Openings</td><td>101,830 [7] Jobs</td><td>109,000 Openings</td><td>93,590 Jobs</td></tr>
</table>

From the data shown here, while very limited, it appears that numerous jobs exist for STEM graduates. Both sides of this debate are more thoroughly explored in the following sections.

The STEM Shortage Debate

For many decades, invested parties have shown concern regarding the quality and quantity of STEM graduates in the United States and globally. In the following two sections the existence of a possible shortage of STEM workers or jobs will be explored.

<u>Deficit in Available STEM Graduates?</u>

Each of the countries listed in Table 2 is worried about a deficit of available STEM workers numbering in the hundreds of thousands [8]. The importance of STEM proficiency has been demonstrated, and numerous countries, including Brazil, South Africa, Singapore, and Australia in addition to those shown in the table below, have doubts about the production of a sufficient STEM workforce [8].

TABLE 2 A profile of STEM shortages

Countries worried about STEM shortages	Deficit Claimed or Projected Need	
United States	1 million additional STEM graduates (Obama report, 2012) [1] [8]; 3 million STEM workers by 2018 [6]	10,000 new engineers per year; 100,000 additional STEM teachers by 2020 (Obama) [1] [8]
India	800 new universities to avoid a deficit of 1.6 million university-educated engineers by 2020	
China	**Growth** 4-year degree graduates in engineering and computer science doubled between 2002 and 2004 [5]	
United Kingdom	100,000 STEM majors per year until 2020 to meet demand (Royal Academy of Engineering) [8]	
Germany	210,000 shortage or workers (MINT—mathematics, computer science, natural sciences, and technology) [8]	

Even China, a country that has demonstrated a high growth rate in its number of STEM graduates, is concerned that it will not have enough to meet the needs of its employers [5]. Industries in the US and other countries in the European Union are advocating for the allowance of more immigrants to fill their gaps in skilled applicants. Invested parties in the US hope to increase the allowable number of H-1B Visas from 65,000 per year to 180,000 per year [8]. The Army Corps of Engineers (ACE), known to some to be largest engineering firm in the world, along with many companies in the US, is worried about replacing its retiring STEM workforce in upcoming years. Up to 41% of the ACE workforce is eligible to retire in 2013 [3]. Because the average STEM worker is about two years older than the average non-STEM worker, it is posited that demand of STEM workers will be greater because of a greater need for replacing retiring workers [9].

It serves as a point of contradiction that nearly 75% of those with STEM degrees work in an area outside of STEM [8]. It may seem logical that if the demand for STEM workers is so great, such a large portion would not be working outside of the STEM fields.

Deficit in Available STEM Jobs?

A current trend in unemployment statistics is that while a percentage of STEM graduates are unemployed, a noticeably higher percentage of non-STEM graduates are unemployed. For example, even though 5.3% of STEM workers were unemployed in 2010 and 4% where unemployed in 2012, their non-STEM counterparts had a 10% unemployment rate in 2010 and 9% in 2012. In 2012, 3% of Tennessee STEM workers were unemployed compared to 10% of non-STEM workers [6].

Despite these trends and the long lasting national and global focus on the shortage of STEM graduates, some are still concerned that more STEM workers exist than STEM jobs [8]. Certain parties cite the lower income of scientific researchers compared to that of doctors and lawyers, as well as the heavy competition for research funding, as an indication that no shortage of scientists exists in the US [9]. Since 2000, salaries for computer and math graduates have reportedly deteriorated and companies like Boeing, IBM, and Symantec have cut thousands of STEM workers [8]. Is this the case because of the declining US economy in recent years, or because a surplus of qualified STEM workers does exist?

Whether or not a deficit in STEM workers or jobs exists, the advancement of qualified, technically capable graduates cannot be overstated [5]. Refined STEM skills are important for any career path, and the US workforce would undoubtably benefit from an improvement in the quality of education for all of its students [8].

Diversity in STEM

Diversity is important from most perspectives, and within STEM the inclusion of a varied population with diverse backgrounds, skills, cultures, genders, and experiences can enhance the overall reasoning processes of a team and improve problem-solving aptitude for the group overall [15]. Despite the importance of diversity, the Army Corps of Engineers acknowledges little progress has been made to incorporate more diversity in its workforce [3]. Many companies and university departments across the US are experiencing the same issue. While 70% of college students in the US are minorities/women, less than half of STEM degrees are awarded to the same set [15]. In 2011, only 18.4% of engineering bachelor's degrees were awarded to women, and only 6.7% of engineering bachelor's degrees were awarded to minorities [11].

Minorities in STEM

The groups of people underrepresented in STEM fields, specifically engineering, include African Americans, Hispanics, Native Americans, and some Asian American groups, as well as women [5]. To reiterate, African Americans, Hispanics, American Indians, and Alaskan natives make up over a quarter of the US population, but only about a 10% portion of the STEM workforce is represented by these same groups [15]. Furthermore, the diversity of the US population is growing and changing to include increasing percentages of minorities, and it is of popular opinion that the STEM representation of these groups should change accordingly [4] [15]. In 2011, it was reported that 8.5% of engineering bachelor's degrees were awarded to Hispanic students and 4% of engineering bachelor's degrees were awarded to African American students [11].

A comprehensive mixture of self-perception, STEM-perception, social stereotypes, economic factors, and cultural discouragement is cited as the reason many African Americans are not attracted to STEM [16]. A number of minority students possess an assumption that STEM is too difficult, and this notion may be fueled by a lack of information or a noted shortage of impactful mentors within multiple groups of underrepresented minorities [16] [17]. Economic factors may hinder diversity in multiple ways. For example, certain cultures have a more immediate need for the smaller paycheck that is instantly attainable, instead of a waiting for a larger salary that may be had in 4-5 or more years [16]. Poorer groups face a disadvantage because they do not possess the financial means needed to attend a college or university [17]. Harvard University calls it a "minor miracle" that low-income minorities students graduate from a four-year university, with the biggest obstacles being a lack of career counseling, tuition increases and other costs, a shortage of financial assistance, and an increased necessity to balance a full course load with an unrelated, equally full work schedule [18]. Even though research dating back to the 1980s has reported an equal desire of Caucasian, African American, and Asian Americans to enter into a STEM major, the proportion of graduates of these backgrounds is not in alignment [17]. This discrepancy may also be due to educational inequality seen as early as elementary or middle school, when less-skilled or educated teachers are employed in less affluent schools [17]. A discrepancy is also seen in high school, where only 3.4% of African

American students and 3.7% of Hispanic students take AP calculus (compared to 7.5% of Caucasian students) [17]. Educational equality factors like these are also relevant to the retention of minorities in STEM majors in college [17]. Where 70% Caucasian students follow through with a STEM degree, only 42% of African American students and 49% of Hispanic students do the same [17].

Women in STEM

Over half of all bachelor's degrees, master's degrees, and doctoral degrees in all fields (not just STEM) are awarded to women today in the US [19]. In 2009, females acquired 62% of all associate's degrees [6]. However, only about 18% of undergraduate engineering students are female in the US [19] [6]. In 2011, the percentage of engineering bachelor's degrees awarded to women was 18.4%, the percentage of engineering master's degrees awarded to women was 22.6%, and the percentage of engineering doctoral degrees was 22.9% [11]. Between 2000 and 2010, roughly 59% of bachelor's degrees in biological sciences where earned by females, and about 50% of bachelor's degrees in chemistry where earned by females [19]. In 2010, only 19% of computer science degrees and 21% of physics degrees where earned by females [6] [20]. It may seem odd that while the majority of college educated people in the US are female, far less than the majority is majoring in certain areas of STEM like engineering, physics, and computer science. This is especially true when realizing that engineering and computer science offer the highest salaries and levels of flexibility [20]. Some mystery exists as to why women are not entering these fields in representative proportions, but the actuality is that gender stereotypes and cultural expectations persist as obstacles for women in STEM today [19] [20].

In 2013, female students are still receiving poor advice regarding entering engineering programs; they are sometimes facing the perception that they are not as skilled as males or should not be entering such a time-consuming career path [19]. Gender stereotypes also dictate that men are more attracted to engineering and other STEM fields because they are better performers in the subjects, even though data proves that women are just as skilled if not more so in STEM [21]. Furthermore, while men may focus on system efficiency, women in engineering seem to care more about helping people [19]. Since the importance of diversity in the workplace has already been strongly promoted, it may be surprising that such attitudes against women still exist. Many attribute female aversion or indifference to STEM to these cultural and gender expectations, and verbal/nonverbal "discouragement" [21]. In fact, some engineering departments in this country still do not have women's restrooms [19].

Male and female opinions of math are said to start diverging at age seven [6]. It has been shown that gender stereotypes start during a student's childhood, and may be demonstrated by the parents themselves [19]. While most middle school girls in a series of focus groups put on by the National Academy of Engineering did assert that women could be engineers, they could only recall male engineers [5]. It seems as if critical examples of women succeeding in the role of engineering or other STEM careers are not being provided, thus fostering the notion that only males are destined to succeed in STEM [5] [20]. The exception to this comes in the case of forensic science, and it serves to provide an example of how the introduction to a successful, strong female scientist (even if on TV) can promote female participation in the same field. Media is credited by some to have shifted forensic science from a majority male to majority female occupation [20].

Even though engineering is not necessarily perceived by society as dull or "uncool", many people consider it to be unattainable, especially women. They may have a belief that engineering is respectable and necessary, just not appropriate or desirable for women [5]. It is not that female students are anti-STEM, but that they find other, non-STEM career paths more appealing [21]. Furthermore, not only are STEM degrees typically more challenging and more time consuming, but it is sometimes also true that attaining one may take an extra type of confidence for women as opposed to men [19].

Recommendations for Diversity Inclusion

Outreach efforts that try to attract minority student populations are emerging and increasingly providing valuable experiences across the US [23]. In addition to these efforts, other suggestions for promoting a diverse STEM population including both females and underrepresented minority groups include concepts like:

- The inclusion of interactive, hands-on, collaborative, and problem solving oriented activities that are obviously applicable to the real world,
- an introduction to influential mentors with a similar appearance to the student,
- the practice of allowing female students to work in all-girl teams until a confidence in basic STEM skills is established,
- the education of teachers, counselors, and parents regarding the necessity of diversity in STEM and the value of a STEM-focused education, and
- the special consideration of underrepresented groups in STEM when promoting or marketing STEM subjects or events [22].

Many organizations throughout the country are implementing these concepts. The South Dakota School of Mines & Technology, for example, has implemented the *Women in Science and Engineering Symposium* and *Girls' Day* in an effort to boost their female percentage from 25%. This same university stresses that not only should women be better positioned in the basic STEM fields, but that they should also be supported in leadership and power roles across multiple industries [23]. The University of San Diego, however, is taking a different approach by simply attempting to fill multiple vacant faculty positions in its engineering department with women [19]. An incentive exists in that for women and minorities, STEM is the best equal opportunity employer [2].

Alternative Opportunities in STEM

The portion of STEM workers streaming straight from high school, community colleges, or vocational programs is often overlooked or uncounted, yet it serves as a crucial part of US technological and economic development [9]. As of 2011, 20% of all jobs required STEM competency; half of all STEM jobs available required less than a four-year degree [9]. With or without a four-year degree, a job in STEM will have higher pay than its non-stem counterpart. In Memphis, Tennessee, STEM jobs requiring at least a bachelor's degree pay an average of 30% more than non-STEM jobs; STEM jobs requiring a high school diploma or two-year technical degree pay 63% higher than their non-STEM counterparts [24]. According to the Department of Commerce's definition of STEM only 43% of STEM workers possess a STEM degree (although they may possess a non-STEM degree) [8].

Only 20% of federally funded STEM promotion efforts are devoted to areas that require less than a bachelor's or four-year degree [9]. About 13 million jobs that pay an average of $53,000 per year exist for STEM workers without a four-year degree. This is about 10% higher than other jobs requiring the same amount of education [9]. While four-year degree STEM jobs tend to be grouped in larger cities, STEM jobs requiring only an associate's degree more evenly blanket the country, and provide significant opportunities in rural communities [9]. The previously under-acknowledged type of STEM role provides strong advantages to those who occupy it.

Educating the STEM Student

While it is possible that that there are not enough STEM students being produced by the current US education system, it is even more probable that students are also not sufficiently educated to meet the country's growing need to advance in STEM fields [1].

STEM in K-12 Education

Success in STEM starts at an early age, so the necessity of a strong educational foundation in elementary and middle school exists [4]. Furthermore, students are more likely to complete STEM degrees when they have an early exposure to discussions about STEM careers [1]. It follows that a quality and well-rounded education is imperative for STEM success even at the youngest levels, but according to the White House, the US K-12 education system ranks in about the middle of the worldwide spectrum [1].

One attempt to improve the US education system includes the concept of standards. The intention is that by providing equal educational opportunities in a thoroughly consistent system, more students will excel in not only STEM, but also literacy [25]. Consistency in quality education in STEM fields for students of all backgrounds is crucial, and can be improved by the implementation of "Common Core State Standards and Next Generation Science Standards" [15]. These standards are designed to be "fewer, clearer, and higher" with the hopes that more collaboration across subject areas and an emphasis on the ability to "argue from evidence" will provide a better education without overburdening the educator [25]. Many sources agree that the bar should be raised such that high school diplomas indicate college preparation instead of the completion of high school.

An additional effort to improve K-12 education includes the role of the teacher. In science specifically, about a third of high school physics and chemistry teachers have earned a degree or certificate in these subjects [1]. Although a gap in research exists regarding the effectiveness of K-12 STEM educators who possess higher-level degrees, a discrepancy is present between low- and high- income school educators: 69% of science teachers in low-poverty schools have advanced degrees, while only 49% have advanced degrees in high-poverty schools [15]. Even though the causal relationship is inconclusive, it seems logical that a preference for a science or STEM teacher with a higher-level degree in his/her field would exist.

As stated previously, STEM success starts early, and to sustain a younger student's interest and attraction to STEM, an extensive set of experiences, both inside and out of the classroom, is desirable. The engagement and accessibility to museums, science centers, and hands-on experiences would further reinforce STEM development [15].

<u>Perceptions of the Engineer</u>

Even though numerous parties and millions of dollars are spent in promoting engineering education and understanding each year, the majority of pre-university students and teachers do not fully understand the value of engineering. Not only would a better appreciation of engineering be useful for sustaining our scientific acumen and STEM capabilities in the US, but the education and awareness of engineering at a young age would also allow students to better prepare for a major of this type in college [5].

In 2008 in an effort to *Change the Conversation* (also the title of this source) that informs US students of the value of engineering, the following statement was developed by the National Academy of Engineering:

> *No profession unleashes the spirit of innovation like engineering. From research to real-world applications, engineers constantly discover how to improve our lives by creating bold new solutions that connect science to life in unexpected, forward-thinking ways. Few professions turn so many ideas into so many realities. Few have such a direct and positive effect on people's everyday lives. We are counting on engineers and their imaginations to help us meet the needs of the 21st century.*

As the developers of this statement tried to conjure up feelings of job satisfaction and prove that engineering is problem-solving for humanity, they deemphasized the requirement for straight-A's in math and science. Ultimately it is interest in these subjects that is most necessary for success in engineering [5]. Initiatives in STEM promotion efforts agree that engineering should be recognized with prestige, and should be able to draw more students with its compelling attractiveness [4].

Higher Education

Of all the STEM fields, the highest number of jobs is found in engineering (closely followed by science) [9]. Many high school students, however, never experience engineering-related curriculum [19]. Perhaps this limited exposure to STEM is the reason why 61% of Tennessee's first-time community college students need remediation in math, costing the state $16,388,664 every year [6]. If a student is not well grounded in the STEM subjects before reaching college, not only will he/she have a more difficult time in an already challenging subject, but the regular occurrence of such a case will also put additional pressure on the educators.

Even after a prospective STEM student has joined a field in a university, retention is an obstacle. Of the students entering college with the intention of earning a

STEM degree, less than 40% complete this goal [8]. To combat this effort, universities across the US have initiated mentoring, networking, and tutoring programs, and it has also been proven that the stronger the relationship between student and professor/advisor is, the higher the chance of STEM retention, especially for undergraduate students in their second year [15].

It is also important that the same industries that employ STEM graduates maintain a relationship with the institutions and universities producing them [4]. For this reason, a better discussion should occur about the needs and wants of STEM employers, while concurrently providing more direct exposure to the opportunities in STEM careers. In one of these discussions, a study in Tennessee found that the essential skills most desired by employers are the same skills they find lacking: verbal communication, basic mathematics, problem solving, teamwork, and critical, independent thinking [26]. By enhancing communication between the institutes of higher education and the industries employing STEM graduates, the quality of the graduate could also be enhanced.

Next Steps for STEM

STEM in the United States

While these challenges exist for the advancement of STEM in the US, many efforts are underway to help promote STEM educational quality and equality and to better align the output of schools with the requirement on the future workforce. Outreach programs, research projects, and fundraising are happening across the country at all age levels. About $4.3 billion is spent each year by the federal government to promote STEM education and training [9]. About $3 billion is devoted to science education, the public perception of science, and the future training of scientists and engineers [27]. The White House declares in its Five Year Strategic Plan that:

> *Whether it be through direct support, provision of expertise and content, mobilization of talented STEM role models and mentors, or by exposing students to real-world learning opportunities at Federal STEM facilities, [agencies across the country are working to] inspire and inform future scientists, engineers, innovators, and explorers [1].*

STEM Workforce

US STEM Workforce

It has been shown that throughout the US, the regions with the highest percentage of STEM workers are those regions with the largest dependence on government funding [10]. Washington, DC is an obvious example, and Los Alamos, NM and Butte, ID are two others; both the later examples house chief US Department of Energy facilities [10]. In 2011, DC had 220% more STEM workers than the average of all the US [10].

Many projections claim an increase of 8.65 million STEM jobs by 2018 [14] [2], and some already report a growth of 8,387,316 STEM jobs in the US in 2011 [10]. In addition, the Labor Department predicts 1.4 million open jobs will exist in computer science over the next decade [20].

Tennessee STEM Workforce

The Tennessee STEM Innovation Network (TSIN) is in place to synchronize the STEM needs of the state's industry sector with the output of its universities and K-12 schools [7]. TSIN focuses on increasing interest and achievement in STEM, cultivating STEM-capable students, expanding access to skilled STEM teachers and mentors, reducing the Tennessee achievement gap, and building a better awareness of STEM throughout the community in an effort to bolster the STEM pipeline between education and industry [7]. The following table shows that Tennessee saw an increase in its general workforce of 4% with an increase in the STEM workforce of 6% between 2001 and 2011.

TABLE 3 Tennessee's Gain in STEM Workforce Concentration [10]

Number of New Jobs (2001-2011)	% Change (All Jobs)	Number of New STEM Jobs	% Change (STEM)	2001 STEM LQ	2011 STEM LQ
119,340	4%	5,888	6%	0.60	0.63

Even still, since an LQ (location quotient) of one means that a state has the same relative portion of STEM workers as the national average, Table 1 shows that Tennessee has consistently possessed roughly 40% less of a STEM concentration of workers that the average in the rest of the US [10].

Not only does information from the Bureau of Labor Statistics and the Georgetown University Center on Education and the Workforce predict an increase in Tennessee STEM jobs of 16.3% between 2008 and 2018, but a new plan also exists developed under the administration of Tennessee Governor Haslam (Jobs4TN) that intends to further increase the number of STEM jobs available [7]. Eighty-eight percent of the 14,000 additional STEM jobs Tennessee will see in the next five years will require postsecondary educations, and 47% of the 14,000 additional STEM jobs will be in computer occupations [7]. Figure 1 below indicates the projected distribution of the educational requirements of STEM jobs across Tennessee in 2018.

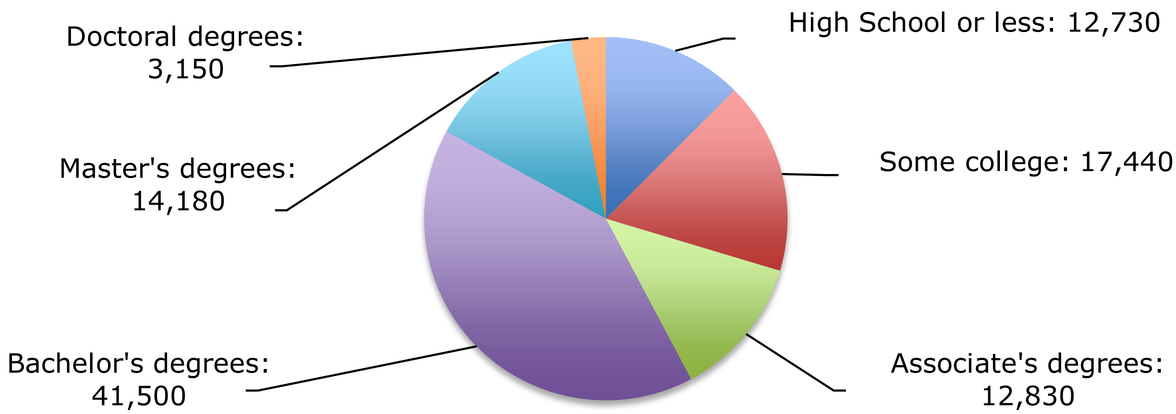

FIGURE 1 2018 Projection of the Distribution of Educational Requirements for STEM Jobs in Tennessee [28]

In addition, an analysis of the supply and demand of STEM workers specific to Tennessee has been performed. Table 4 shows the deficit or surplus of workers expected annually between 2008 and 2018.

TABLE 4 Supply and Demand of STEM Career Paths in Tenn. through 2018 [7] [29]

STEM Career Path	Average **Graduates**/Year (Associate's Degree or Higher) 2008-2018	Average **Openings**/Year (Associate's Degree or Higher) 2008-2018	Average Annual Graduate Deficit/Surplus
Programming and Software Development	281	678	**-397**
Environmental Service Systems	0	149	**-149**
Construction	88	200	**-112**
Biotechnology Research and Development	23	70	**-48**
Animal Systems	114	146	**-32**
Information Support and Services	334	345	**-11**
Plant Systems	338	334	**4**
Food Products and Processing Systems	31	9	**22**
Design Preconstruction	210	182	**28**
Natural Resources Systems	182	35	**147**
Manufacturing Production Process Development	213	33	**180**
Transportation Operations	236	38	**198**
Maintenance, Installation and Repair	481	45	**436**
Network Systems	912	454	**458**
Engineering and Technology	1,929	608	**1,321**
Science and Mathematics	5,827	300	**5,527**

Programming and software development, environmental service systems, and constructions paths represent three of the largest areas in need of more STEM graduates and are indicated in red in Table 4, while careers paths with a surplus of graduates are shown in green. Currently, roughly 2,500 job openings exist in

Tennessee. Over the next ten years, the total number STEM occupations in Tennessee is expected to grow by 11.5% [30].

West Tennessee STEM Workforce

The following section proves that when focusing specifically on the West Tennessee region a fair amount of data already exists and has been published related to labor trends, but it is necessary that more research be done in order to accurately identify the skill gaps and workforce production needs in this part of the state. The following tables set the stage for identifying areas where workforce is needed as well as which levels of education and which types of skills are needed in West Tennessee.

Table 5 will provide the population of labor force in various regions as well as the unemployment rates of the counties compared to statewide and nationwide figures. Table 6 will provided a definition of the three Local Workforce Investment Areas (LWIAs) in West Tennessee, and it will also indicated the number and percentage of degrees awarded for these LWIAs and Tennessee. Tables 7-9 indicate the most needed jobs within each of LWIAs in West Tennessee, and they provide the education required, average number of job openings per year, median salary in 2012, and the type and degree of STEM skill required for each job. The jobs are presented in order of highest annual average openings. Finally, Table 10 highlights the most needed jobs that require an associate's degree or higher within each LWIA in West Tennessee.

TABLE 5 Labor Force Data for LWIA 12, June 2013 [31] 2012 [30]

	Labor Force	Employed	Unemployed	Unemployment Rate	Source
US	**157,089,000**	**144,841,000**	**12,248,000**	**7.8%**	**36**
Tennessee	**3,143,300**	**2,865,800**	**277,500**	**8.8%**	**36**
LWIA 11					
Weakley	16,370	14,440	1,940	13.43%	40
Henry	13,720	12,320	1,400	11.36%	
Benton	6,950	6,240	710	11.38%	
Carroll	13,800	12,300	1,500	12.20%	
Haywood	8,770	7,790	980	12.58%	
Madison	49,730	45,650	4,080	8.94%	
Henderson	12,510	11,190	1,320	11.80%	
Chester	8,380	7,670	710	9.26%	
Decatur	5,750	5,200	550	10.58%	
Hardeman	10,910	9,700	1,200	12.37%	
McNairy	10,730	9,690	1,040	10.73%	
Hardin	12,160	11,000	1,150	10.45%	
LWIA 12	**151,920**	**133,870**	**18,030**	**11.8%**	**36**
Shelby	435,210	395,790	39,420	9.96%	40
Fayette	17,650	15,900	1,740	10.94%	
LWIA 13					
Lake	2,800	2,510	290	11.55%	40
Obion	14,480	12,550	1,930	15.38%	
Dyer	17,220	15,220	2,000	13.14%	
Gibson	21,260	18,800	2,460	13.09%	
Lauderdale	9,920	8,680	1,230	14.17%	
Crockett	6,830	6,130	700	11.42%	
Tipton	28,420	25,900	2,520	9.73%	

Table 5 shows unemployment rates varying from 7.8% nationwide to the highest rate in Lauderdale County of 14.17%. This table is incomplete as it does not include the numbers for LWIA 11 or 13. It should also be noted that the rates shown for individual counties are from 2012, while the other, less-aggregated rates are from June 2013.

Table 6 below is important as it shows that the population of West Tennessee is only earning 16.4% (less than 1/5) of the degrees statewide. Tennessee's total population was 6.456 million (in 2012) while the counties of West Tennessee had a total population of 1.575 million (in 2012) according to the US Census.

TABLE 6 Summary of Total Degrees Awarded in 2008 [29]

LWIA	West Tennessee Counties	Total Awards	
		Number	Percentage of Total
11	Benton, Carroll, Chester, Decatur, Hardeman, Hardin, Haywood, Henderson, Henry, McNairy, Madison, and Weakley Counties	4,108	7%
12	Crockett, Dyer, Gibson, Lake, Lauderdale, Obion and Tipton Counties	207	0.4%
13	Fayette and Shelby Counties	9,023	15.4%
TOTAL FOR TENNESSEE		58,571	100%

That is, West Tennessee makes up roughly 1/4 or 24.4% of the population of the entire state, yet the region is only producing 22.8% of the degrees statewide.

The following three tables (Tables 7-9) indicate the "Hot Careers to 2020" in Tennessee. According to the Tennessee Department of Labor, these careers are in demand, have shown positive job growth, and have at least 120 job openings per year [32] [33] [34]. The jobs shown in Tables 7-9 in this paper have been additionally filtered to highlight those that could be considered STEM careers. Careers with a moderate skill requirement in at least two of the three subjects of math, science, or computer programming were considered to be STEM. Also, careers with an advanced math skill requirement were considered to be STEM jobs.

TABLE 7 "Hot Jobs" in STEM in LWIA 11 [32]

Benton, Carroll, Chester, Decatur, Hardeman, Hardin, Haywood, Henderson, Henry, McNairy, Madison, and Weakley counties

Job Title	Education	2012-2020 Avg. Annual Openings	Salary	Math	Science	Computer Programming
Accountants and Auditors	Bachelor's degree	840	$49,579	●		
Financial Managers	Bachelor's degree	335	$73,986	●		
Computer Systems Analysts	Bachelor's degree	285	$60,796	●	○	●
Loan Officers	Bachelor's degree	260	$61,888	●		
Child, Family, and School Social Workers	Bachelor's degree	220	$34,820*	○	●	
Physical Therapists	Master's degree	215	$83,210	○	●	
Directors, Religious Activities and Education	Bachelor's degree	210	$54,510*	○	○	
Computer Programmers	Bachelor's degree	200	$56,880	●	○	●
Healthcare Social Workers	Bachelor's degree	180	$46,843	○	●	
Computer and Information Systems Managers	Bachelor's degree	155	$80,410	○	○	○
Mental Health Counselors	Master's degree	145	$30,070	○	●	
Medical and Clinical Laboratory Technologists	Bachelor's degree	135	$56,105	○	●	○
Mental Health and Substance Abuse Social Workers	Master's degree	130	$31,559	○	●	
Financial Analysts	Bachelor's degree	130	$57,274	●		
Software Developers, Applications	Bachelor's degree	130	$67,832	●	○	●
Industrial Engineers	Bachelor's degree	120	$73,727	●		
Software Developers, Systems Software	Bachelor's degree	120	$68,466	●	○	●
Elementary School Teachers, Except Special Ed.	Bachelor's degree	70	$41,999	●	○	
Farmers, Ranchers, and Other Agricultural Managers	Bachelor's degree	65	$34,050*	○	●	
Secondary School Teachers, Except Special and Career/Technical Education	Bachelor's degree	45	$43,731	●	○	
Bookkeeping, Accounting, and Auditing Clerks	Moderate-term on-the-job training	30	$28,578	●		
Plumbers, Pipefitters, and Steamfitters	Long-term on-the-job training	25	$33,798	○	○	

Billing and Posting Clerks	Moderate-term on-the-job training	25	$27,921	○		○
First-Line Supervisors of Food Preparation and Serving Worker	Work experience in a related occ.	20	$22,533	●		
Pharmacy Technicians	Moderate-term on-the-job training	20	$26,457	●	○	
Dental Assistants	Moderate-term on-the-job training	15	$33,869	○	○	
Sales Managers	Bachelor's degree	10	$80,999	●		
Emergency Medical Technicians and Paramedic	Post-secondary vocational training	10	$29,483	○	●	
First-Line Supervisors of Farming, Fishing, and Forestry	Work experience in a related occ.	10	$64,326	○	●	
Firefighters	Long-term on-the-job training	10	$28,454	○	○	
First-Line Supervisors of Retail Sales Worker	Work experience in a related occ.	5	$32,662	●		
First-Line Supervisors of Construction Trades and Extraction Worker	Work experience in a related occ.	1	$43,992	○	○	
First-Line Supervisors of Non-Retail Sales Worker	Work experience in a related occ.	1	$64,044	●		

In Benton, Carroll, Chester, Decatur, Hardeman, Hardin, Haywood, Henderson, Henry, McNairy, Madison, and Weakley counties the three hottest careers are Accountants and Auditors, Financial Managers, and Computer Systems Analysts, all of which require a bachelor’s degree.

TABLE 8 "Hot Jobs" in STEM in LWIA 12 [33]

Crockett, Dyer, Gibson, Lauderdale, Lake, Obion, and Tipton counties

Job Title	Education	2012-2020 Avg. Annual Openings	2012 Median Salary	Math	Science	Computer Programming
Accountants and Auditors	Bachelor's degree	840	$47,198	●		
Financial Managers	Bachelor's degree	335	$68,814	●		
Computer Systems Analysts	Bachelor's degree	285	$37,244	●	○	●
Loan Officers	Bachelor's degree	260	$49,692	●		
Child, Family, and School Social Workers	Bachelor's degree	220	$35,252	○	●	
Physical Therapists	Master's degree	215	$85,396	○	●	
Directors, Religious Activities and Education	Bachelor's degree	210	$54,510*	○	○	
Computer Programmers	Bachelor's degree	200	$45,965	●	○	●
Healthcare Social Workers	Bachelor's degree	180	$46,356	○	●	
Computer and Information Systems Managers	Bachelor's degree	155	$64,361	○	○	○
Mental Health Counselors	Master's degree	145	$30,882	○	●	
Medical and Clinical Laboratory Technologists	Bachelor's degree	135	$51,710	○	●	○
Mental Health and Substance Abuse Social Workers	Master's degree	130	$42,050	○	●	
Financial Analysts	Bachelor's degree	130	$68,430*	●		
Software Developers, Applications	Bachelor's degree	130	$58,962	●	○	●
Industrial Engineers	Bachelor's degree	120	$69,704	●		
Software Developers, Systems Software	Bachelor's degree	120	$81,750*	●	○	●
Elementary School Teachers, Except Special Education	Bachelor's degree	55	$42,208	●	○	
Registered Nurses	Associate's degree	55	$51,450	○	●	
Secondary School Teachers, Except Special and Career/Technical Education	Bachelor's degree	40	$43,787	●	○	
First-Line Supervisors of Retail Sales Workers	Work experience in a related occ.	35	$33,769	●		
First-Line Supervisors of Food Preparation and Serving Workers	Work experience in a related occ.	20	$23,067	●		

Bookkeeping, Accounting, and Auditing Clerks	Moderate-term on-the-job training	20	$27,187	●		
First-Line Supervisors of Construction Trades and Extraction Workers	Work experience in a related occ.	15	$48,105	○	○	
Electricians	Long-term on-the-job training	15	$40,706	○	●	
Medical Assistants	Moderate-term on-the-job training	15	$23,428	○	○	
Pharmacy Technicians	Moderate-term on-the-job training	15	$27,622	●	○	
First-Line Supervisors of Non-Retail Sales Workers	Work experience in a related occ.	10	$47,471	●		
Billing and Posting Clerks	Moderate-term on-the-job training	10	$27,947	○		○

In Crockett, Dyer, Gibson, Lauderdale, Lake, Obion, and Tipton counties the three hottest careers are the same as in LWIA 11: Accountants and Auditors, Financial Managers, and Computer Systems Analysts.

TABLE 9 “Hot Jobs” in STEM in LWIA 13 [34]

Fayette and Shelby counties

Job Title	Education	2012-2020 Avg. Annual Openings	2012 Median Salary	Math	Science	Computer Programming
Accountants and Auditors	Bachelor's degree	840	$57,065	●		
Registered Nurses	Associate's degree	515	$60,595	○	●	
Financial Managers	Bachelor's degree	335	$86,843	●		
Computer Systems Analysts	Bachelor's degree	285	$80,985	●	○	●
Loan Officers	Bachelor's degree	260	$59,015	●		
Child, Family, and School Social Workers	Bachelor's degree	220	$35,989	○	●	
Physical Therapists	Master's degree	215	$80,607	○	●	
Directors, Religious Activities and Education	Bachelor's degree	210	$54,510*	○	○	
Computer Programmers	Bachelor's degree	200	$75,790	●	○	●
Elementary School Teachers, Except Special Education	Bachelor's degree	200	$52,321	●	○	
Healthcare Social Workers	Bachelor's degree	180	$53,145	○	●	
First-Line Supervisors of Retail Sales Workers	Work experience in a related occ.	160	$38,042	●		
Computer and Information Systems Managers	Bachelor's degree	155	$107,830	○	○	○
Mental Health Counselors	Master's degree	145	$34,491	○	●	
Licensed Practical and Licensed Vocational Nurses	Post-secondary vocational training	140	$39,342	○	●	
Medical and Clinical Laboratory Technologists	Bachelor's degree	135	$59,372	○	●	○
Mental Health and Substance Abuse Social Workers	Master's degree	130	$38,848	○	●	
Financial Analysts	Bachelor's degree	130	$68,436	●		
Software Developers, Applications	Bachelor's degree	130	$80,278	●	○	●
Bookkeeping, Accounting, and Auditing Clerks	Moderate-term on-the-job training	130	$35,435	●		
Industrial Engineers	Bachelor's degree	120	$80,560	●		
Software Developers, Systems Software	Bachelor's degree	120	$79,817	●	○	●
Secondary School Teachers, Except Special and Career/Technical Education	Bachelor's degree	110	$52,907	●	○	

Automotive Service Technicians and Mechanics	Post-secondary vocational training	110	$44,331	○	○	
Electricians	Long-term on-the-job training	105	$43,448	●	○	
First-Line Supervisors of Food Preparation and Serving Workers	Work experience in a related occ.	95	$24,921	●		
Executive Secretaries and Executive Administrative	Moderate-term on-the-job training	85	$40,445	○		○
Billing and Posting Clerks	Moderate-term on-the-job training	70	$33,519	○		○
First-Line Supervisors of Non-Retail Sales Workers	Work experience in a related occ.	65	$85,589	●		
Sales Managers	Bachelor's degree	60	$85,606	●		
Medical and Clinical Laboratory Technicians	Associate's degree	55	$40,121	○	●	
Firefighters	Long-term on-the-job training	55	$52,346	○	○	
Management Analysts	Bachelor's degree	50	$77,994	○	○	
Network and Computer Systems Administrators	Bachelor's degree	50	$68,725	○	○	●
Plumbers, Pipefitters, and Steamfitters	Long-term on-the-job training	50	$43,167	○	○	
Radiologic Technologists and Technicians	Associate's degree	45	$47,650*	○	●	
Training and Development Specialists	Bachelor's degree	40	$66,457	○	○	
First-Line Supervisors of Construction Trades and Extraction Workers	Work experience in a related occ.	40	$52,011	○	○	

The hottest jobs in Fayette and Shelby County differ from those in LWIA 11 and 12. Registered nurses are in high demand, a career requiring at least an associate’s degree.

The following table serves to highlight the hottest jobs in each of West Tennessee’s LWIA regions, while showing only the careers that require at least an associate’s degree.

TABLE 10 West Tennessee STEM Job Forecast of “Hot Jobs” requiring at least an associate’s degree until 2018 by LWIA Region [35]

Title	Average Annual Wage	Average Annual Openings	Jobs Outlook	Education or Training Requirement
LWIA 11: Benton, Carroll, Chester, Decatur, Hardeman, Hardin, Haywood, Henderson, Henry, McNairy, Madison, & Weakley Counties				
Physical Therapist	$76,834	20	Favorable	Master's degree
Respiratory Therapist	$35,620	5	Favorable	Associate degree
LWIA 12: Crockett, Dyer, Gibson, Lake, Lauderdale, Obion & Tipton Counties				
Registered Nurses	$54,369	60	Excellent	Associate degree
LWIA 13: Fayette & Shelby Counties				
Computer & Information Systems Managers	$93,205	25	Excellent	Bachelor's or higher degree, plus work experience
Pharmacists	$114,258	45	Very Good	First professional degree
Physical Therapists	$77,769	25	Favorable	Master's degree
Engineering Managers	$99,404	15	Favorable	Bachelor's or higher degree, plus work experience
Computer Systems Analysts	$70,350	50	Excellent	Bachelor's degree
Network Systems & Data Communications Analysts	$75,017	50	Excellent	Bachelor's degree
Network & Computer Systems Administrators	$67,819	40	Excellent	Bachelor's degree
Logisticians	$48,183	35	Excellent	Bachelor's degree
Computer Software Engineers, Systems Software	$72,439	45	Very Good	Bachelor's degree
Registered Nurses	$60,169	485	Excellent	Associate degree
Licensed Practical & Licensed Vocational Nurses	$41,629	230	Excellent	Postsecondary vocational training
Computer Support Specialists	$44,161	75	Excellent	Associate degree
Environmental Science & Protection Technicians, Including Health	$44,614	10	Very Good	Associate degree
Radiologic Technologists & Technicians	$52,065	30	Very Good	Associate degree

It is important to note that while in LWIA 13 many of jobs in high demand require at least an associate's degree. This is not true for LWIA 12 and 11 where only a few require this level of education. Such a difference indicates that a high school level STEM certification program would be very valuable in LWIA 11 and 12.

Conclusions

While a significant amount of data was found during the research for this paper, it is apparent from the numerous conflicting sources that many questions remain unanswered pertaining to STEM education and workforce needs. For West Tennessee, a more detailed investigation of employer needs, skills gaps, and worker shortages should be undertaken. This information is necessary to truly inform efforts to transform STEM education and appropriately prepare students for the 21st century workforce.

References

1. "Federal Science, Technology, Engineering, and Mathematics (STEM) Education: 5 - Year Strategic Plan." *Committee on STEM Education*. National Science and Technology Council, May 2013. Web. 10 Feb. 2013. <www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf>.
2. Smith, Nicole. "STEM: Science, Technology, Engineering, Mathematics." *College and Career Readiness and Success Center*. Georgetown Center on Education and the Workforce, n.d. Web. 1 Feb. 2014. <http://www9.georgetown.edu/grad/gppi/hpi/cew/pdfs/stem-complete.pdf>.
3. Serbu, Jared. "Army Corps of Engineers worries about a shrinking pool of talent." *Federal New Radio | 1500 AM*. N.p., 14 Aug. 2013. Web. 2 Oct. 2013. <http://www.federalnewsradio.com/397/3421175/Army-Corps-of-Engineers-worrie>.
4. *Educating the Engineer of 2020 Adapting Engineering Education to the New Century.* Washington, D.C.: National Academies Press, 2005. Print.
5. Changing the Conversation: Messages for Improving Public Understanding of Engineering. Washington, D.C.: National Academies Press, 2008. Print.
6. "Why STEM? STEM is the Future." *Changing the Equation- Improving learning in science, technology, engineering and mathematics*. changingtheequation.org, n.d. Web. 2 Oct. 2013. <http://changetheequation.org/why-stem>.
7. "Tennessee STEM Strategic Plan." *The Tennessee STEM Innovation Network*. N.p., 1 Aug. 2012. Web. 1 Feb. 2014. <http://thetsin.org/strategic-plan/>.
8. Charette, Robert N. "The STEM Crisis Is a Myth." *IEEE Spectrum: Technology, Engineering, and Science News*. IEEE Spectrum, 30 Aug. 2013. Web. 2 Oct. 2013. <http://spectrum.ieee.org/at-work/education/the-stem-crisis-is-a-myth>.
9. Rothwell, Jonathan. "The Hidden STEM Economy." *Brookings.* Brookings Institution, 10 June 2013. Web. 2 Oct. 2013. <http://www.brookings.edu/research/reports/2013/06/10-stem-economy-rothwell>.
10. Wright, Joshua. "States with Largest Presence of STEM-Related Jobs." *EMSI Economic Modeling Specialists Intl*. Economic Modeling Specialists Intl., a CareerBuilder Company, 20 Sept. 2011. Web. 1 Feb. 2012. <http://www.economicmodeling.com/2011/ 09/20/where-are-stem-jobs-concentrated/>.
11. Yoder, Brian L. "Engineering by the Numbers." *ASEE Publications*. American Society for Engineering Education, 1 Jan. 2012. Web. 1 Feb. 2012. <http://www.asee.org/papers-and-publications/publications/college-profiles/2011-profile-engineering-statistics.pdf>.
12. Langdon, David, George McKittrick, David Beede, Beethika Khan, and Mark Doms. "STEM: Good Jobs Now and for the Future." *U.S. Department of Commerce Economics and Statistics Administration*. Version #03-11. Office of the Chief Economist, 1 July 2011. Web. 1 Feb. 2014. <http://www.esa.doc.gov/sites/default/files/reports/documents/stemfinalyjuly14_1.pdf>.

13."Tennessee Higher Education Factbook." *Tennessee Higher Education Commission*. Version 2012-2013. Tennessee Government, 14 Jan. 2001. Web. 14 Feb. 2001. <http://www.state.tn.us/thec/Legislative/Reports/2013/2012-2013%20Factbook.pdf>.

14.My College Options. "Where are the STEM Students?" *STEM Connector*. Version 2012-2013. Diversified Search, n.d. Web. 1 Feb. 2014. <http://www.stemconnector.org/sites/default/files/store/STEM-Students-STEM-Jobs-Executive-Summary.pdf>.

15.Ferrini-Mundy, Joan. "Driven by Diversity." *Science* 340.6130 (2013): 278. *Science Magazine*. Web. 2 Oct. 2013.

16.Zhao, Emmeline. "STEM Education And Jobs: Declining Numbers Of Blacks Seen In Math, Science." *Huff Post Education*. The Huffington Post, 24 Oct. 2011. Web. 24 July 2014. <http://www.huffingtonpost.com/2011/10/24/stem-education-and-jobs-d_n_1028998.html>.

17."10 Startling Stats About Minorities in STEM - Online Universities." *Online Universities*. N.p., 17 June 2012. Web. 12 Feb. 2014. <http://www.onlineuniversities.com/blog/2012/06/10-startling-stats-about-minorities-stem/>.

18."Pathways to Prosperity." *Pathways to Prosperity Project*. Harvard Graduate School of Education, 1 Feb. 2011. Web. 1 Feb. 2014. <http://www.gse.harvard.edu/news_events/features/2011/Pathways_to_Prosperity_Feb2011.pdf>.

19.Robbins, Gary. "Why so few women in engineering?" *San Diego News, Local, California and National News.* UTSanDiego.com, 12 Sept. 2013. Web. 2 Oct. 2013. <http://www.utsandiego.com/news/2013/Sep/12/women-engineering/?#article-copy>.

20.Rampell, Catherine. "I Am Woman, Watch Me Hack." *The New York Times*. The New York Times, 26 Oct. 2013. Web. 1 Feb. 2014. <http://www.nytimes.com/2013/10/27/magazine/i-am-woman-watch-me-hack.html?h%3Ep&_r=2&>.

21.Bonar, Samantha. "Study: Women Don't Choose STEM Careers Despite Their Skills." *Tech Page One.* N.p., 3 May 2013. Web. 2 Oct. 2013. <http://www.techpageone.com/business/study-women-stem-careers/#.UkxDZWSif4N>.

22.Baine, Celeste. "Women and Minorities in STEM Careers Advancing our World." *STEM White Paper*. McGraw-Hill Education Global, n.d. Web. 1 Feb. 2014. <https://www.mheonline.com/glencoemath/pdf/stem_careers.pdf>.

23."STEMinism: The hottest trend in tech." *The Hardrock* Summer (2013): 8. *South Dakota School of Mines & Technology*. Web. 2 Oct. 2013.

24.McKenzie, Kevin. "Study highlights Memphis-area STEM jobs without four-year degree." *The Commercial Appeal: Local Memphis, Tennessee News Delivered Throughout the Day*. Scripps Interactive Newspapers Group, 15 June 2013. Web. 2 Oct. 2013. <http://www.commercialappeal.com/news/2013/jun/15/study-highlights-memphis-area-stem-jobs-without/>.

25. Stage, E.K., H. Asturias, T. Cheuk, P.A. Daro, and S.B. Hampton. "Opportunities and Challenges in Next Generation Standards." Science 340 (2013): 276-277. *Science Magazine*. Web. 2 Oct. 2013. http://ell.stanford.edu/sites/default/files/Science-2013-Stage-276-7.pdf
26. "TAKING INVENTORY Job Skills in the Tennessee Workforce." *Tennessee Diploma Project*. Tennessee Business Roundtable and Hyde Family Foundations, Oct. 2007. Web. 2 Oct. 2013. <www.sitemason.com/files/bdcRJm/takinginventoryreport%202.pdf>.
27. Mervis, Jeffrey. "Wild Cards Remain After Proposed Reshuffle of STEM Education." Science 340.6130 (2013): 258-259. *Science Magazine*. Web. 2 Oct. 2013. <http://www.sciencemag.org/content/340/6130/258.full>.
28. "Pathways to Prosperity." *Pathways to Prosperity Project*. Harvard Graduate School of Education, 1 Feb. 2011. Web. 1 Feb. 2014. <http://www.gse.harvard.edu/news_events/features/2011/Pathways_to_Prosperity_Feb2011.pdf>.
29. Luna, LeAnn, Matthew N. Murray, and Vickie C. Cunningham. "Academic Program Supply and Occupational Demand Projections: 2008â€"2018." *Tennessee Higher Education Commission*. Center for Business and Economic Research College of Business Administration the University of Tennessee Knoxville, Tennessee, 1 Apr. 2011. Web. 1 Feb. 2014. <http://www.state.tn.us/thec/Divisions/AcademicAffairs/academic_programs/THEC%20supply%20and%20demand%20Final.pdf>.
30. Townsend, Ted. "State of Tennessee." 2014 Innovations in STEM Education Conference. TN Economic and Community Development. University of Memphis - Lambuth, Jackson, TN. 14 May 1925. Speech.
31. "Report to the Community, Northwest Tennessee Workforce Board Annual Report 2012-2013." *Tennessee Career Centers*. Version 2012-2013. The Northwest Tennessee Career Center, 1 Aug. 2013. Web. 1 Feb. 2014. <http://www.northwesttncareercenter.org/ANNUAL_REPORT_2012_2013.pdf>.
32. Wettemann, Martha. "LWIA 11 Hot Careers to 2020." *Tennessee Government*. N.p., n.d. Web. 1 Feb. 2014. <http://www.tn.gov/labor-wfd/outlooks/lwia11.pdf>.
33. Wettemann, Martha. "LWIA 12 Hot Careers to 2020." *Tennessee Government*. N.p., n.d. Web. 1 Feb. 2014. <http://www.tn.gov/labor-wfd/outlooks/lwia12.pdf>.
34. Wettemann, Martha. "LWIA 13 Hot Careers to 2020." *Tennessee Government*. N.p., n.d. Web. 1 Feb. 2014. <http://www.tn.gov/labor-wfd/outlooks/lwia13.pdf>.
35. "Tennessee Job Outlook." *Tennessee Department of Labor and Workforce Development - Index*. Tennessee Department of Labor and Workforce Development, n.d. Web. 1 Feb. 2014. <http://www.state.tn.us/labor-wfd/outlooks/select.htm>.