What is a STEM job?

How Different Interpretations of the Acronym Result in Disparate Labor Market Projections

Amanda Oleson, Matthew Hora and Ross J. Benbow

VIEWPOINT PAPER #1 • SEPTEMBER 2014

Science, technology, engineering, and mathematics, more ubiquitously known by the acronym "STEM," have received a substantial amount of attention over the past several years. This attention is based largely on the belief that innovation in these fields has historically played a central role in creating new industries and jobs in the United States and abroad, and that to maintain the dominant role of the United States in a globalized marketplace, students and workers must become well versed in the STEM disciplines. For example, the President's Council of Advisors on Science and Technology argues that the nation will need one million more STEM professionals so the United States can "retain its historical preeminence in science and technology" (President's Council of Advisors on Science and Technology, 2012, p. 1).

This goal highlights the view that a workforce skilled in the STEM fields plays a critical role in the economic future of the United States. Consequently, the apparent lack of workers skilled in these areas is viewed as a considerable problem and is often cited as a reason for slow job growth and recovery from the 2008 Great Recession. Sometimes called the "skills gap," the belief exists that there are many good-paying jobs, but the U.S. workforce is inadequately prepared to fill them largely due to the failures of the educational system. The idea of a skills gap and the central role of education in addressing it is a widely

KEY FINDINGS:

1. Estimates of STEM jobs in the United States vary from 5.4 million to 26 million, depending on which occupations are included under the STEM umbrella and how occupations are defined. This results in wildly disparate projections for jobs, wages, and required education for what may appear to be a single cluster of occupations (i.e., STEM).
2. In their analyses, many analysts overlook blue-collar occupations that require STEM knowledge, which results in (a) under-counting the number of STEM-related jobs, (b) inflating wage estimates for the STEM job category, and (c) under-estimating the value of non-baccalaureate postsecondary education.
3. When interpreting labor market data, policymakers and analysts should not make broad generalizations about STEM jobs or entire industries without carefully specifying the occupation (e.g., electrical engineering, front-line factory work) being discussed.

WCER
WISCONSIN CENTER FOR EDUCATION RESEARCH

THE CENTER ON
Education and Work
UNIVERSITY OF WISCONSIN–MADISON

accepted (although not uncontested) idea in education and workforce development policy, such that funds are increasingly allocated to training and education programs that target "high-demand" jobs, many of which are considered to be in STEM fields.

As part of a research study investigating the alignment (or lack thereof) between the goals and priorities of educators and employers, we found it difficult to ascertain precisely what constituted a STEM occupation and to reconcile vastly different job, wage, and educational attainment projections.

Yet, as part of a research study investigating the alignment (or lack thereof) between the goals and priorities of educators and employers, we found it difficult to ascertain precisely what constituted a STEM occupation and to reconcile vastly different job, wage, and educational attainment projections. For example, whether or not fields such as healthcare or blue-collar occupations are included or excluded from labor market analyses have significant implications for the resulting number of jobs, potential wages, and the type of education and training needed to qualify for one of these jobs.

As educational researchers new to the field of workforce development and labor market economics, we were confused and felt compelled to dig a little deeper to understand why projections for STEM jobs ranged from 5.4 to 26 million, and wages for these jobs from $50,000 to $96,000. Thus, we posed the following questions:

1. What exactly is a STEM occupation and how are they classified by different agencies and researchers?
2. How do the number of projected STEM jobs, their wages, and the education required to attain them vary according to different definitions of STEM occupations?

We are not the first to argue that the STEM acronym is problematic. Most parties agree that there is no universally accepted way to define a STEM occupation or group of STEM occupations (e.g., United States Congress Joint Economic Committee, 2012) and that different studies use different criterion and definitions (Thomasian, 2011). Because of this problem, in 2012 the Standard Occupational Classification Policy Committee (SOCPC) gathered and proposed options for defining STEM occupations[1] to be used across federal agencies.

Until a standardized understanding of STEM occupations is adopted, the status quo is problematic because depending on how STEM occupations are categorized resulting analyses will vary considerably. The stakes are high for students and adult workers making decisions about their education and future careers. Policymakers allocate funds for programs and initiatives, schools and colleges tailor their curricula, and students select programs (and subsequently accrue increasing amounts of debt) often on the basis of which fields labor market experts project to be "high-demand" currently and into the future.

"These are the wrong times for inadequate information on jobs and skill requirements" (p. 1).
— Carnevale, Smith, and Strohl (2010)

However, in the case of STEM occupations, which are invariably near or at the top of many experts' lists of well-paying jobs into the 21st century, depending on which expert the policymakers, educators, or students rely on, they will come up with very different conclusions about their policies, curricula, and future career choices. As Carnevale, Smith, and Strohl (2010), argue, given persistently high unemployment and the rapidly evolving nature of work, "These are the wrong times for inadequate information on jobs and skill requirements" (p. 1).

We wholeheartedly agree and hope that this paper reveals the issues associated with the ubiquitous "STEM" acronym so that a more accurate approach to discussing jobs and skills in these fields can be developed and disseminated.

[1] For the remainder of this paper, we use "job" and "occupation" interchangeably.

Part 1: What Exactly Is a STEM Occupation?

In this section we discuss two central issues to the problem of the STEM acronym when discussing occupations: how occupations in general are classified and organized and how government agencies and researchers determine which occupations fit into the STEM category.

How Occupations Are Classified and Organized

Underlying all decisions about what is or is not a STEM occupation is the determination of what distinguishes one occupation from another. On this point, the Bureau of Labor Statistics' (BLS) Standard Occupational Classification (SOC) system is the most widely used by labor market researchers in both government and academia. The SOC organizes occupations in groups based on "similar job duties, and in some cases, skills, education and/or training" (Bureau of Labor Statistics, n.d).

Another system for classifying and organizing occupations is called O*Net, an online career resource that allows users to explore occupations based on skills, knowledge, abilities, interests, work activities, work contexts, work values, or tools and technologies used on the job. While occupations in the O*Net system are largely based on the SOC system, users can explore differences and similarities across occupations based on additional criteria. For example, one can browse occupations in O*Net by Career Cluster, which contains "occupations in the same field of work that require similar skills" (O*Net OnLine, n.d.a), Job Family (the SOC major groups), Job Zone (required level of education, experience, and training), STEM Discipline, and Industry.

How STEM Occupations are Determined

Determining which occupations or groups of occupations should be considered "STEM" involves two decisions: (1) what types of criteria (e.g., nature of work performed, skills, education or degree field, knowledge, type of worker[2]) should be used to determine what is (and is not) a STEM occupation, and (2) which occupational categories (e.g., production, healthcare) should be included under the broader designation of STEM occupations. Our analysis indicates that researchers and government agencies vary considerably on both of these counts. See Table 1 for a summary of how the six agencies described in this section classify STEM occupations.

Occupations and Industries are not Synonymous

Too often the media or researchers take data about growth occupations such as electrical engineering and draw conclusions about industry growth. It is important to recognize that industries as a whole, such as manufacturing, do not employ just one occupational type. Rather, occupations as diverse as electrical engineers, managers, sales, and production workers are commonly found in the manufacturing industry. This knowledge is vital because each occupational type has different growth and wage potential, as well as educational requirements—even within the same industry. Thus, when speaking about job and wage growth, as well as desirable educational pathways, speaking in terms of occupations instead of industries is preferable.

Bureau of Labor Statistics. Researchers at the BLS selected a variety of occupations from the SOC system to create their own definitions of STEM occupations. These occupations were mostly drawn from three SOC major groups: architecture and engineering occupations; computer and mathematical occupations; and life, physical, and social science occupations. For example, in one report BLS analysts included categories such as management, education and training, and sales occupations in the STEM category (Vilorio, 2014). One point of variation among BLS publications was whether occupations in the social sciences were included in the STEM category.

[2] "Type of worker" refers to the distinction between professional and non-professional jobs, or what are more colloquially known as "blue-collar" or "white-collar" occupations.

Table 1. Classification of STEM occupations by agency

	SOCPC[a]	O*Net – STEM Career Cluster[b]	NSF[c]	CEW at Georgetown[d]	CEW at Georgetown[e]	Rothwell (2013) - High STEM in any Field	Rothwell (2013) - Super-STEM, Combined Fields
Criteria by which occupations are classified	Work task (SOC)	Skills	Work task (SOC)	Work task (SOC)[f]	Work task (SOC)	STEM Knowledge (based on O*Net knowledge scores)	STEM Knowledge (based on O*Net knowledge scores)
Specification of STEM-related occupations	Yes	No	Yes	No	No	No	No
BLS SOC detailed occupations	184 detailed occupations	170 detailed occupations	62 detailed occupations	85 detailed occupations	95 detailed occupations	N/A detailed occupations[g]	N/A detailed occupationsg
BLS SOC major groups	7 (management; computer & mathematical; architecture & engineering; life, physical, & social science; education, training, & library; healthcare practitioner & technical; sales & related)	10 (architecture & engineering; management; education, training, & library; business & financial operations; life, physical, & social science; arts, design, entertainment, sports, & media; office & administrative support; computer & mathematical; community & social services; healthcare practitioners & technical)	3 (computer & mathematical; architecture & engineering; life, physical, & social science)	3 (computer & mathematical; architecture & engineering; life, physical, & social science)	3 (computer & mathematical; architecture & engineering; life, physical, & social science)	N/A major groups	N/A major groups

[a] SOC Policy Committee (2012); based on 2010 SOC
[b] Based on O*Net's variation of BLS-SOC detailed occupations (decimal system); http://www.onetonline.org/find/career?c=15&g=Go
[c] NSB (2014) Based on 2000 SOC; S&E occupations; also measures S&E and S&E-related workforce based on education and use of expertise on the job
[d] Carnevale, Smith, & Melton (2011); based on 2010 SOC
[e] Carnevale, Smith, & Strohl, (2010); based on 2000 SOC; includes social science occupations
[f] Their analysis is based on SOC, which is work-task based. Yet they include technician and technologist occupations because of the required technical skills
[g] Military specific occupations were not considered, detailed occupational data were not provided

Standard Occupational Classification Policy Committee (SOCPC). In 2012 the SOCPC convened and proposed options for defining STEM occupations. They determined that STEM occupations consisted of occupations within two domains: (1) the science, engineering, mathematics, and information technology domain, and (2) the science- and engineering-related domain. Within each of these primary domains are two subdomains. Within the science, engineering, mathematics, and information technology domain are the subdomains of (1A) life and physical science, engineering, mathematics, and information technology occupations, and (1B) social science occupations. This domain is considered to contain the "core" STEM occupations (Jones, 2014). Within the science- and engineering-related domain are the subdomains of (2A) architecture occupations and (2B) health occupations (SOC Policy Committee, 2012). The science- and engineering-related domain includes occupations that are assumed to depend on STEM knowledge (Jones, 2014). This approach introduces an important distinction between "core" and "related" or peripheral STEM occupations.

The SOCPC also defined STEM in terms of five *types* of STEM occupations within each subdomain: (I) research, development, design, or practitioner occupations, (II) technologist and technician occupations, (III) postsecondary teaching occupations, (IV) managerial occupations, and (V) sales occupations. The detailed occupations defined as "STEM" using this organizational scheme included 184 detailed occupations (SOC Policy Committee, 2012). See Table 2 for the organizational scheme of the SOCPC's STEM occupations.

Table 2. The SOCPC's standardized definition of STEM occupations

Types of Occupations in Each Domain	(1) Science, Engineering, Mathematics, and Information Technology Domain	(2) Science- and Engineering-Related Domain
(I) Research, development, design, or practitioner occupations (II) Technologist and technician occupations (III) Postsecondary teaching occupations (IV) Managerial occupations (V) Sales occupations	(1A) Life and physical science occupations Engineering occupations Mathematics occupations Information technology occupations (1B) Social science occupations	(2A) Architecture occupations (2B) Health occupations

O*Net. While O*Net does not clearly specify what it means by a "STEM" job, users can search jobs by Career Cluster (occupations organized by similar skills in the same field of work). The STEM Career Cluster includes occupations from 10 SOC major groups such as computer and mathematical occupations, architecture and engineering occupations, and life, physical, and social science occupations are included, with the notable inclusion of healthcare practitioners and technical occupations. The STEM Career Cluster identifies a wider range of occupations than the SOCPC's grouping of STEM occupations.

Additionally, users can search occupations in O*Net by STEM Discipline, which identifies occupations that requires STEM education in chemistry, computer science, engineering, environmental science, geosciences, life sciences, mathematics, and physics/astronomy (O*Net OnLine, n.d.b). These STEM disciplines are paired with occupations found in 15 SOC major groups, notably including occupations within the following SOC major groups: healthcare practitioners and technical occupations; production occupations; and installation, maintenance, and repair occupations.

National Science Foundation (NSF). In its *Science and Engineering Indicators 2014* report, the NSF measures the science and engineering (S&E) workforce three ways: (1) those working in S&E occupations; (2) those holding a degree in an S&E field; and (3) whether or not a worker uses technical expertise at the bachelor's level in one or more S&E fields[3] (National Science Board [NSB], 2014). The NSF's method of organizing STEM occupations also utilizes a "core" and "related" distinction similar to the one used by the SOCPC in its definition of STEM occupations.

For example, when measuring the S&E workforce by those working in certain occupations, the classification system used by the NSF places certain SOC occupations into one of three categories: (1) S&E occupations *are generally associated* with a bachelor's degree in any S&E field and include "life scientists, computer and mathematical scientists, physical scientists, social scientists, and engineers" (NSB, 2014, p. 3-8), along with postsecondary instructors teaching those disciplines; (2) S&E-related occupations *still require S&E knowledge or training, but not necessarily a bachelor's degree in an S&E field.* S&E-related occupations include "health-related occupations, S&E managers, S&E technicians and technologists, architects, actuaries, S&E precollege teachers, and postsecondary teachers in S&E-related fields" (NSB, 2014, p. 3-8); and, (3) Non-S&E occupations, or jobs in which workers will still use S&E technical expertise, but their position may not be a formal S&E occupation or require a degree in an S&E field (NSB, 2014).

According to the NSF, STEM specifically refers to "the part of the labor force that works with S&E" (NSB, 2014, p. 3-8). Thus, most of the STEM workforce operates in occupations that are S&E occupations, with only some of the STEM workforce operating in occupations classified as S&E-related (e.g., managers, technicians and technologists).

[3] There are many ways in which the NSF conceptualizes STEM, but the definition one selects seems to largely depend on what one wants to look at. For example, one can measure the S&E workforce by the number of individuals whose highest degree is in an S&E field AND who work in an S&E occupation. The ways that the S&E workforce is parsed out within NSF are many and varied. For the remainder of this paper, we primarily focus on occupation and degree field as measurement of the S&E workforce, while also noting that many other definitions exist.

Classifying STEM Occupations as "Core" or "Related"

The SOCPC's options for defining STEM occupations splits those STEM occupations into two domains, one of which is said to contain the "core" of STEM jobs, while the other domain (science and engineering-related) contains occupations "dependent upon STEM knowledge" (Jones, 2014). Beyond Jones (2014), no rationale is given for the split between the two domains.

The NSF's S&E occupations typically require a bachelor's degree in an S&E field, while the S&E-related occupations may not require a bachelor's degree in an S&E field (NSB, 2014). The NSF seems to use education as a way of separating S&E occupations from S&E-related occupations.

Compare the SOCPC's and the NSF's "core" and "related" occupations in Table A. One can see that they are relatively similar, with the exception of how the technologist and technician occupations and the managerial occupations that are relegated to the NSF's S&E-related occupations are found throughout both domains of the SOCPC's definition of STEM. Further, according to the NSF, sales occupations are considered non-S&E occupations, but sales occupations are found throughout both of the SOCPC's STEM domains.

Table A. Comparisons between "Core STEM" and "STEM-Related" occupations for the SOCPC and the NSF

	SOCPC	NSF
STEM/ S&E	**Science, Engineering, Mathematics, and Information Technology Occupations:** Life and physical science Engineering Mathematics Information technology Social science (Includes the following types: Research, development, design, or practitioner; technologist and technician; postsecondary teaching; managerial; and sales)	**S&E Occupations:** Biological, agricultural, and environmental life scientists Computer and mathematical scientists Physical scientists Social scientists Engineers S&E postsecondary teachers
STEM/ S&E-Related	**Science- and Engineering-Related Occupations:** Architecture Health (Includes the following types: Research, development, design, or practitioner; technologist and technician; postsecondary teaching; managerial; and sales)	**S&E-Related Occupations:** Health S&E managers S&E precollege teachers S&E technicians and technologists Architects Actuaries S&E-related postsecondary teachers

Center on Education and the Workforce at Georgetown University. In *Help Wanted,* a report focusing on the educational attainment needed to acquire the jobs of the future, authors Carnevale, Smith, and Strohl (2010) defined STEM using detailed occupations from the following SOC major groups: computer and mathematical occupations, architecture and engineering occupations, and life, physical, and social science occupations. In another report called *STEM: Science, Technology, Engineering and Mathematics,* Carnevale, Smith, and Melton (2011) determined that STEM occupations include detailed occupations from the same major occupations denoted in their *Help Wanted* report, although this particular analysis excluded the social sciences. This report also includes workers at the sub-baccalaureate level. These two reports published by the CEW indicate that even among researchers in a particular setting, approaches to defining STEM occupations can vary.

Brookings Institution (Rothwell, 2013). In the Brookings Institution report *The Hidden STEM Economy,* Rothwell (2013) argues that a large number of STEM jobs go unnoticed due to the attention researchers and the media pay to occupations requiring a bachelor's degree or higher. He suggests that a variety of jobs may require some degree of STEM knowledge (including technical and blue collar work), and he proposes a new method for classifying STEM jobs.

Using O*Net knowledge scores in biology, chemistry, physics, computers and electronics, engineering and technology, and mathematics, Rothwell (2013) calculated gradations of STEM knowledge required in occupations, and he classified STEM occupations as either: (1) "High STEM in any one field," or (2) "Super-STEM" or "High-STEM across fields." In classifying the extent of STEM in occupations based on what knowledge workers needed for their jobs, Rothwell (2013) argues that "half of all STEM jobs are in manufacturing, health care, or construction industries" (p. 1), and that "installation, maintenance, and repair occupations constitute 12% of all STEM jobs. . . .Other blue-collar or technical jobs in fields such as construction and production also frequently demand STEM knowledge" (Rothwell, 2013, p. 1).

Thus, Rothwell (2013) advances a unique conception of STEM occupations by explicitly including workers in blue-collar jobs and those operating at the sub-bachelor's level based on the fact that workers in these categories often use some form of STEM knowledge. A primary contribution of Rothwell's work is the argument that the national dialogue over STEM occupations has improperly favored the professional occupations in ways that undercount the number of STEM jobs and denigrate blue-collar work that requires significant knowledge of certain STEM disciplines.

Part 2: STEM Job Numbers and Wage Estimates

Next, we examine how the different ways that agencies categorize STEM occupations influence estimates about both the number of current and future STEM jobs and how much these jobs pay.

STEM job or S&E job number estimates range from 5.4 million to 26 million

Current job estimates in STEM fields. Table 3 shows that agencies using a more inclusive definition of STEM across occupations, type of worker (i.e., blue or white collar), knowledge required on the job, and degree field estimate a higher number of STEM workers in the workforce. It also demonstrates how data gathered in different years and using different sources has a significant effect on job estimates. Across the board, STEM job or S&E job number estimates range from 5.4 million to 26 million.

Table 3. Comparing STEM occupations current job numbers, projections. and wage estimates across agencies

	SOCPC[a]	O*Net–STEM Career Cluster[b]	NSF–S&E Workforce Measured by Occupation[c]	NSF–S&E Workforce Measured by Degree Field[c]	NSF–S&E Workforce Measured by Expertise[c]	CEW at Georgetown[d]	CEW at Georgetown (includes social science)[e]	Rothwell (2013)-High STEM in any Field	Rothwell (2013) -Super-STEM, Combined Fields
Estimated # of jobs	16,944,480 (May 2013)[f]	12,950,000 (2012)[g]	S&E occupations: 5,398,000 (2010)[h] 5,968,000 (2012)[i]	At least one degree in S&E field: 19,493,000 (2010) Highest degree in S&E field: 14,457,000 (2010)[j]	16,456,000 (2010)[k]	~6,800,000 (2008)[l]	~7,300,000 (2008)[m]	26,000,000 (2011)	N/A
Projected # of jobs	N/A	4,034,000 (projected openings due to growth and replacement, 2012-2022)[n]	In all S&E occupations: 6,585,000 (Projected employment, 2020)[o]	N/A	N/A	~8,000,000 (All jobs, 2018)[p]	~8,600,000 (All jobs, 2018)[q]	N/A	N/A
Estimated wages	$79,640.00 (May 2013)[r]	$73,698.94 (2013)[s]	In S&E occupation: $82,930.00 (2012) In STEM occupation: $82,160.00 (2012) In S&E-related occupation: $74,840 (May 2012)[t]	Highest degree in S&E field working in S&E occupation $78,000 (2010) Highest degree in S&E field in S&E-related occupations: $65,000 (2010) Highest degree in S&E-related field in S&E occupation: $72,000 (2010) Highest degree in S&E-related field in S&E-related occupation: $70,000 (2010)[u]	N/A	$61,000 (architects, surveyors, and technicians) $64,000 (life and physical science occupations) $73,000 (computer occupations) $77,000 (mathematical science occupations) $78,000 (engineering and engineering technician occupations) (2005-2009)[v]	$71,569.00 (2008)[w]	Above $52,000, less than a bachelor's degree Nearly $88,000, bachelor's degree and above (2011)	Above $50,000, less than a bachelor's degree Nearly $96,000, bachelor's degree and above (2011)[x]

Table 3 Notes: Comparing STEM occupations current job numbers, projections. and wage estimates across agencies

[a] Jones (2014)
[b] http://www.onetonline.org/find/career?c=15&g=Go
[c] NSB (2014)
[d] Carnevale, Smith, & Melton (2011)
[e] Carnevale, Smith, & Strohl (2010)
[f] Source: Jones (2014), reporting analysis of BLS OES data (May, 2013)
[g] Source: Our addition of employment estimates provided by O*Net for each detailed occupation in the STEM Career Cluster; BLS Employment Projections program (2012-2022)
[h] Source: NSB (2014), reporting analysis of NSF/NCSES SESTAT (2010); bachelor's and above
[i] Source: NSB (2014), reporting analysis of BLS OES data (2012); all levels of education
[j] Source: NSB (2014), reporting analysis of NSF/NCSES SESTAT (2010); bachelor's and above
[k] Source: NSB (2014), reporting analysis of NSF/NCSES SESTAT National Survey of College Graduates (NSCG) (2010); bachelor's and above
[l] Source: Carnevale, Smith, & Melton (2011)
[m] Source: Carnevale, Smith, & Strohl (2010)
[n] Source: Our addition of projected job openings provided by O*Net for each detailed occupation in the STEM Career Cluster; BLS Employment Projections program (2012-2022)
[o] Source: NSB (2014), reporting analysis of BLS Employment Projections program (2010-2020)
[p] Source: Carnevale, Smith, & Melton (2011)
[q] Source: Carnevale, Smith, & Strohl (2010)
[r] Source: Jones (2014), reporting analysis of BLS OES data (May, 2013); annual average wages
[s] Source: Our average of annual median salary data provided by O*Net for each detailed occupation in the STEM Career Cluster; BLS OES (2013)
[t] Source: NSB (2014), reporting analysis of BLS OES data (May 2012); all levels of education; all education fields; mean annual earnings
[u] Source: NSB (2014), reporting analysis of NSF/NCSES NSCG (2010); bachelor's and above; median annual salary
[v] Source: Carnevale, Smith, & Melton (2011); reporting analysis of U.S. Census Bureau ACS (2005-2009); average annual earnings
[w] Source: Carnevale, Smith, & Strohl (2010); reporting authors' analysis of March CPS data for various years, average wage by occupation; workers were full-time and full-year
[x] Source: Rothwell (2013); annual average wages

How is this discrepancy possible? Consider an example from two organizations that categorize occupations based on the SOC system, that both use the OES dataset, and that make their estimates one year apart. Jones (2014) estimated that in 2013, according to the standardized definition of STEM developed by the SOCPC (across both domains), there were almost 17 million workers in STEM jobs. In contrast, analyses by the NSF using their own definition of S&E occupations, estimated that about 5.9 million workers were in the S&E workforce just one year earlier in 2012 (NSB, 2014)—a mere one third of the estimate using the SOCPC's definition. This discrepancy occurs because different occupations are included in their analyses. For example, the SOCPC analysis includes individuals working in healthcare and social science occupations, as well as individuals in relevant managerial, sales, and technician roles. The NSF, however, does not include workers in healthcare occupations or people in managerial, sales, and technician roles when discussing S&E occupations.

The data in Rothwell's (2013) report also demonstrates how using more inclusive criteria (including any job that requires STEM knowledge either in one STEM field or across STEM fields) to categorize STEM jobs results in higher job estimates. Rothwell (2013) estimated there were 26 million High-STEM jobs in the United States in 2011—a number that stands out among the estimates generated by other agencies.

Estimating the size of the S&E workforce based on degree field has an inflating effect as well. The NSF's measure of the S&E workforce using education credentials (i.e., if a person earned a degree in an S&E field or if a person earned his or her highest degree in an S&E field) increases the estimated number of workers in the S&E workforce because more individuals receive S&E or S&E-related degrees than who work in S&E or S&E-related occupations. In 2010, using these measures resulted in estimates of the S&E workforce being almost 3 to 4 times the size of the S&E workforce as measured by occupation for that same year (NSB, 2014).

Projected job numbers in STEM fields. Employment forecasts are a significant resource for policymakers and others with an interest in tailoring public policy to projected high-demand areas in the labor market. Again, where analysts who employ a more inclusive categorization of STEM jobs project a higher number of future STEM jobs than those who use a more restrictive definition.[4]

First, in its *Science and Engineering Indicators 2014* report, the NSF projected total employment in S&E occupations to be over 6.5 million in 2020 (NSB, 2014). Again, S&E occupations usually require a bachelor's degree in an S&E field. Yet, in their report, STEM, researchers at the CEW predicted there would be about 8 million STEM jobs in 2018, and their analysis included individuals at the sub-bachelor's degree level as well as those with a bachelor's degree or higher (Carnevale et al., 2011). In their *Help Wanted* report, researchers at the CEW predicted 8.6 million STEM jobs would exist in 2018 (Carnevale et al., 2010). The variation between those reports from the CEW can be partially explained by the different years the estimates were made and the inclusion of social science occupations in *Help Wanted.*

Finally, the O*Net system's STEM Career Cluster projects four million job openings, due to growth or replacement, will be found in STEM fields in 2022. Although this does not reflect total employment in 2022, O*Net offers another way of looking at jobs and job projections: by openings instead of total number of jobs or total employment.

Wage estimates for STEM workers. Besides estimates of current and projected jobs in STEM fields, researchers also offer estimates of available wages. Again, these figures vary considerably depending on which occupations and types of workers, particularly blue- vs. white-collar jobs, are included in the analysis.

Researchers that give one average salary or even a range of salaries for a group of occupations defined as STEM tend to ignore occupation-specific salaries that may skew those averaged numbers upwards. For example, according his analysis of the SOCPC's options for defining STEM jobs, Jones (2014) found that STEM workers (those in both core and related domains) in 2013 earned almost $80,000 per year, which is almost 1.7 times the national annual average salary of $46,440. Yet, upon closer inspection one discovers substantial variability among job categories. The highest wages in Jones' (2014) analysis are for managerial positions in architecture ($136,540) and the lowest are for technicians in health occupations ($45,200). These examples illustrate the range of wages available in STEM fields and the broad range of occupations that can be included in the category.

Rothwell's (2013) two definitions of STEM occupations (i.e., High STEM and Super-STEM) captured the widest range of average annual earnings. In jobs requiring High STEM knowledge in one field, workers earned an average of over $52,000 (less than a bachelor's degree) to nearly $88,000 (a bachelor's degree or higher) in 2011 depending on the worker's level of educational attainment. In Super-STEM jobs, the range was wider – a worker with less than a bachelor's degree made about $50,000, while a worker with a bachelor's degree or higher earned an average of almost $96,000 per year in 2011.

Therefore, depending on how STEM occupations are categorized, the resulting estimates for current and future jobs, as well as for expected earnings, will vary considerably. A more inclusive definition of STEM occupations (e.g., ones that include healthcare, social science, or blue-collar occupations) inflate the number of jobs estimated, change the estimated wages those workers make, and alter the number of projected jobs.

[4] We report these numbers using language reflected in the individual reports, which mostly project "employment" or "number of STEM jobs," while we also report how one agency projects job numbers in terms of openings due to growth or replacement jobs.

Part 3: The Types of Education and Training Required to Obtain a STEM Job

Different conceptions of what constitutes a "STEM occupation" also lead to different estimates about the type of education and training an individual needs to get such a job. Educational attainment (e.g., degree field or level) is used in two important ways in the literature: (1) as a criterion to initially classify STEM jobs or the workforce, and (2) as a variable that is associated with numbers of STEM jobs and potential earnings.

Classifying STEM Occupations or Workforce on the Basis of Education

As previously noted, educational attainment can be used in both explicit and implicit ways to initially classify what constitutes a STEM occupation. The NSF explicitly uses education to classify STEM jobs when it measures the S&E workforce by the field of the degree held by the individual. The NCSES SESTAT survey used by the NSF to determine the S&E or S&E-related workforce based on degree field only includes those with a bachelor's degree. Thus, when the NSF reports its estimates of the S&E or S&E-related workforce based on degree field (i.e., S&E or S&E-related degree fields), only those workers holding a bachelor's degree are represented.

Instances where the use of educational attainment is used implicitly as a way to classify STEM workers is the precise issue raised by Rothwell (2013) in his argument that most conceptualizations of the "STEM economy" favor professional occupations that require a bachelor's degrees or higher. The exclusion of occupational categories that do require STEM knowledge (e.g., production, healthcare, and construction), Rothwell (2013) argues, not only leads to skewed STEM job number estimates, but also to an overemphasis on 4-year degrees and white-collar work at the expense of technical education and blue-collar work.

The exclusion of occupational categories that do require STEM knowledge (e.g., production, healthcare, and construction), Rothwell (2013) argues, not only leads to skewed STEM job number estimates, but also to an overemphasis on 4-year degrees and white-collar work at the expense of technical education and blue-collar work.

In Table 4, which is based on data included in Rothwell's (2013) report, we include estimates for the types of educational requirements for different conceptions of STEM occupations. Rothwell's categories of "High-STEM" and "Super-STEM," which refer to the STEM knowledge required for a job, are in the first two columns, with the remaining columns using the classification schemes from the CEW and the NSF.

Table 4. STEM Jobs by Educational Requirements and Professional Classification by Various Sources and Definitions, 2011 (Rothwell, 2013)*

	AGENCY			
	Rothwell (2013) High-STEM Any Field	Rothwell (2013) Super-STEM Combined Fields	CEW at Georgetown[a]	NSF[b]
Share (%) of total by most significant educational requirement				
Less than a High School Diploma	2%	0%	0%	0%
High School Diploma or Equivalent	13%	11%	5%	4%
Postsecondary Certificate	17%	18%	1%	1%
Associate Degree	19%	10%	15%	13%
Bachelor's Degree	37%	43%	71%	65%
Master's Degree	6%	4%	6%	8%
Doctoral or Professional Degree	7%	14%	3%	8%
Other Characteristics				
Nonprofessional occupations	31	29	0	0
Share of all U.S. Jobs	20	9	4	5

* Reproduced from Rothwell (2013), p. 8.
[a] Carnevale, Smith, & Melton (2011).
[b] S&E occupations only.

Using Rothwell's (2013) definitions of STEM, half of "High-STEM" jobs required a bachelor's degree or higher and 61% of "Super-STEM" jobs required a bachelor's degree or higher in 2011; in contrast, using researchers' definition of STEM from the CEW, there was an estimated 80% of STEM jobs that required a bachelor's degree or higher in 2011. Similarly, using the NSF's definition of S&E occupations, according to Rothwell, there were an estimated 81% of S&E jobs that required a bachelor's degree or higher in 2011. Furthermore, according to Rothwell's analysis, at least 13% of High STEM jobs and 11% of Super-STEM jobs were available to workers with a high school diploma in 2011. These numbers stand in stark contrast to the estimated 5% or less of STEM/S&E jobs available for similarly qualified workers according to the definitions employed by researchers at the CEW and the NSF.

These results highlight the disparities among educational attainment estimates based simply on varying classification criteria for what constitutes a STEM occupation.

Projections for Educational Requirements for Future STEM Jobs

The issue of classification is also important when projecting the types of education required to get a STEM job in the future. Analyses of this type are perhaps the most influential for students and adult workers who are thinking about their future career opportunities. For example, in their 2010 report, Help Wanted, Carnevale et al. (2010)

Moving forward, one of the critical questions to address in relation to STEM occupations and educational attainment is precisely how many jobs in these fields are truly available for those without a bachelor's degree, and what sort of salary can workers in these jobs expect?

project that in 2018 there will be 2.8 million job openings in STEM fields, with the following educational requirements: 779,000 jobs available for workers with master's degrees or higher; 1.2 million jobs available for workers with bachelor's degrees; 313,000 jobs available for workers with associate degrees; 274,000 jobs available for workers with some college but no degree; 210,000 jobs available for high school graduates; and 9,000 jobs available for high school dropouts.

Ultimately, the authors conclude that regardless of field, some form of postsecondary attainment is crucial for young Americans as they embark on their careers, as the value of a college degree (in contrast to a high school diploma) is approximately $1.6 million in additional earnings.

Further, in their analysis, the authors distinguished among STEM, blue-collar, healthcare, and education occupations. For STEM jobs alone, the authors estimate that 92% will require some postsecondary education, but about 20% of those jobs in 2018 will only require some college or an associate degree, which reflects a substantial number of jobs that do not require a bachelor's, master's, or doctoral degree. It is worth noting that Rothwell (2013), who did not project educational requirements for STEM jobs in the future, estimated that a much higher percentage of STEM jobs (about half), some of which are clustered in blue-collar occupations, are available to workers without a bachelor's degree. Moving forward, one of the critical questions to address in relation to STEM occupations and educational attainment is precisely how many jobs in these fields are truly available for those without a bachelor's degree, and what sort of salary can workers in these jobs expect?

Conclusions

What does a STEM job really mean in practice?

While some may argue that the amount of attention being paid to STEM fields in the labor market is justified given its centrality in the 21st-century global economy, this paper questions the very focus of that attention: What does a STEM job really mean in practice? When President Obama refers to rewarding education-industry partnerships that focus on STEM jobs and skills, what types of educational programs and companies are being referred to?

These are critical questions, because workforce development and education policy is increasingly focusing on "closing the gap" between employer needs (i.e., demand) and educational programming (i.e., supply). Regardless of whether a skills gap does in fact exist (see Kiviat, 2012; Levine, 2013), the rapidly evolving nature of work will require educators to be nimble and responsive to the new technologies, skills, and types of knowledge demanded in the 21st-century workplace (Carnevale et al., 2010). But when occupations in STEM fields are being discussed, defining what is meant by a STEM job is critical in order to ensure that policymakers, researchers, educators, and students are actually talking about growth estimates, earnings potential, and educational requirements for the same thing.

As we have demonstrated in this paper, the issue is not simply being more precise about whether one is talking about the "S" or the "E" in STEM: The type of job (i.e., especially blue- or white-collar) and whether fields such as healthcare are being included as a STEM occupation are matters that need to be explained far more explicitly in the media and public policy debates. Whether one is speaking about doctoral-level quality control engineers or front-line factory workers, both of whom are included in some definitions of STEM jobs, will also result in dramatically different conclusions regarding the opportunity and future earnings suggested by the catch-all term "STEM jobs."

Similarly, it is imperative to recognize the distinction between STEM jobs and jobs that require STEM knowledge or STEM skills. In an interview regarding the skills gap, Carnevale stated, "STEM jobs account for about

5 percent of all jobs in the economy. STEM competencies, however, valued outside of traditional STEM jobs – account for 40% of all jobs" (Sarachan, 2013). Thus, there is a significant difference between STEM jobs in their strictest definition and jobs that simply require STEM competencies. This difference, analogous to that recognized by Rothwell (2013) also has similar implications for what workers should expect from their jobs in terms of opportunities and wages as well as the education they would need to get those jobs.

Thus, our primary recommendations to the field are:

1. When making claims about the labor market in regard to STEM-related occupations, do not make broad generalizations about "STEM jobs" or entire industries (e.g., manufacturing) without specifying the exact occupation (e.g., electrical engineering) being discussed.

2. Be explicit about the definition of STEM occupations being used in any given analysis and consider one of the two following options: (a) The standardized definition for STEM occupations developed by the SOCPC; or, (b) Employ comprehensive definitions of STEM occupations that encompass those that utilize varying degrees of STEM disciplinary knowledge (e.g., O*Net knowledge scores) and/or those that may not require a bachelor's degree (e.g., blue collar occupations).

We suggest that the spotlight should remain on STEM jobs and the types of degrees and certificates required to get them, but with a slightly different focus. In our own research program exploring the alignment (or lack thereof) between postsecondary education and employer expectations (see http://alignmentstudy.wceruw.org), we are finding that in some cases hiring and promotion decisions have less to do with an applicant's qualifications on paper than on their demonstrated aptitudes in a variety of skill and knowledge areas. With these issues in mind, the focus of attention shifts somewhat from the types of degrees or certificates required to get that high-paying STEM job to the types of skills and aptitudes that educators and employers should focus on cultivating and those that students should seek to acquire. Focusing on how to teach, train, and acquire a broader set of skills beyond just technical expertise in a single field is one of the ways that the United States can cultivate a workforce that will be prepared to succeed in the 21st-century economy and beyond.

Focusing on how to teach, train, and acquire a broader set of skills, knowledge, and personal attributes (e.g., work ethic values, critical thinking, adaptability) beyond just technical expertise in a single field is one of the ways that the United States can cultivate a workforce that will be prepared to succeed in the 21st-century economy and beyond.

References

Bureau of Labor Statistics. (n.d). *Standard occupational classification.* Retrieved from http://www.bls.gov/soc/home.htm

Bureau of Labor Statistics. (2013a, Dec 9). Employment projections—2012–2022. [News release]. Retrieved from http://www.bls.gov/news.release/pdf/ecopro.pdf

Bureau of Labor Statistics. (2013b). Occupational employment statistics: Occupational employment and wages, May 2013. Retrieved from http://www.bls.gov/oes/current/oes290000.htm

Carnevale, A. P., Smith, N., & Melton, M. (2011). *STEM: Science, technology, engineering, mathematics.* Washington, D.C.: Georgetown University.

Carnevale, A. P., Smith, N., & Strohl, M. (2010). *Help wanted: Projections of jobs and education requirements through 2018.* Washington, D.C.: Georgetown University.

Competitive Wisconsin (2012). *Be Bold 2: Growing Wisconsin's talent pool.* Retrieved from http://www.competitivewi.com/wp-content/uploads/2012/10/BeBold2_Study_October2012.pdf

Jones, J. I. (2014). An overview of employment and wages in science, technology, engineering, and math (STEM) groups. Beyond the numbers: Employment and unemployment, 3(8). Retrieved from http://www.bls.gov/opub/btn/volume-3/an-overview-of-employment.htm

Kiviat, B. (2012, July). The big jobs myth: American workers aren't ready for American jobs. The Atlantic. Retrieved from http://www.theatlantic.com/business/archive/2012/07/the-big-jobs-myth-american-workers-arent-ready-for-american-jobs/260169/

Levine, M. V. (2013). The skills gap and unemployment in Wisconsin: Separating fact from fiction. Milwaukee, WI: Center for Economic Development, University of Wisconsin–Milwaukee.

National Center for O*NET Development (n.d). Content Model. O*NET Resource Center. Retrieved from http://www.onetcenter.org/content.html

National Science Board. (2014). *Science and engineering indicators 2014.* Arlington, VA: National Science Foundation (NSB 14-01).

O*Net OnLine. (n.d.a). *Browse by career cluster.* Retrieved from http://www.onetonline.org/find/career

O*Net OnLine (n.d.b). *Browse by STEM discipline.* Retrieved from http://www.onetonline.org/find/stem?t=0&g=Go

Pellegrino, J. W., & Hilton, M. L. (Eds.). (2012). Education for life and work: Developing transferable knowledge and skills in the 21st century. Washington, D.C.: National Academies Press.

President's Council of Advisors on Science and Technology (2012). *Report to the President. Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering and mathematics.* Washington, D.C.: Executive Office of the President.

Rothwell, J. (2013). *The hidden STEM economy.* Washington D.C.: Brookings Institution.

Sarachan, S. (2013, Feb 1). Ask the experts: Skills gap. Need to Know on PBS. Retrieved from http://www.pbs.org/wnet/need-to-know/economy/ask-the-experts-skills-jobs/16219/

SOC Policy Committee (2012). Attachment A: Options for defining STEM (science, technology, engineering, and mathematics) occupations under the 2010 standard occupational classification (SOC) system. Retrieved from http://www.bls.gov/soc/Attachment_A_STEM.pdf

Thomasian, J. (2011). *Building a science, technology, engineering, and math education agenda: An update of state actions.* Washington D.C.: National Governor's Association Center for Best Practices.

United States Congress Joint Economic Committee. (2012). *STEM Education: Preparing for the jobs of the future.* Washington, D.C. Retrieved from http://www.jec.senate.gov/public//index.cfm?a=Files.Serve&File_id=6aaa7e1f-9586-47be-82e7-326f47658320

United States Governmental Accountability Office. (2014). *Science, technology, engineering, and mathematics education: Assessing the relationship between education and the workforce.* GAO-14-374. Washington, D.C.

Vilorio, D. (2014). STEM 101: Intro to tomorrow's jobs. Occupational Outlook Quarterly, 58(1), 2–12.

White House Office of the Press Secretary (2013, Feb 12). Remarks by the president in the state of the union address. Washington, D.C. Retrieved from http://www.whitehouse.gov/the-press-office/2013/02/12/remarks-president-state-union-address

For more information about this study contact Amanda Oleson at aoleson@wisc.edu. This study is being supported by the National Science Foundation (DGE #1348648) and the Center on Education and Work at the University of Wisconsin-Madison.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.