STEM: How a Poorly Defined Acronym Is Shaping Education and Workforce Development Policy in the United States

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STEM: How a Poorly Defined Acronym Is Shaping Education and Workforce Development Policy in the United States

Amanda K. Oleson, Matthew T. Hora, and Ross J. Benbow

The fields of 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, such as the invention of the internal combustion engine or the development of the Internet, has historically played a central role in creating new industries and jobs in the United States and abroad. Thus, the conventional wisdom says that in order 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 if the United States is to "retain its historical preeminence in science and technology" (President's Council of Advisors on Science and Technology, 2012, p. 1).

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 STEM is determined (work tasks, knowledge, skills, degree field). This results in a significant problem with how the acronym is used in labor market analyses.
2. 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.

This goal of one million more STEM workers highlights the view that a workforce skilled in the STEM fields will play 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. In fact, the lack of skilled workers 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. Indeed, the idea of a skills gap and the central role of education in addressing it has become a fundamental and accepted principle 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.

"And we'll reward schools that develop new partnerships with colleges and employers, and create classes that focus on science, technology, engineering, and math—the skills today's employers are looking for to fill the jobs that are there right now and will be there in the future" (President Obama, White House Office of the Press Secretary, 2013).

Yet, as part of a research program investigating the alignment (or lack thereof) between postsecondary education and workforce needs, we discovered troubling issues surrounding the way that projections are made about the number of STEM jobs available, their expected wages, and the education needed to get these jobs: Projections and subsequent policy recommendations were based on different definitions of what precisely a "STEM occupation" is. Thus, 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. For example, estimates for the number of STEM jobs range from 5.4 million to 26 million, and average wages exhibit a similarly large range of $50,000 to $96,000.

Thus, 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.

The realization that there were inconsistencies in the projections for STEM jobs cited in the media and by policymakers led us to pose the following questions:

1. What exactly is a STEM occupation and how are these jobs 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 certainly not the first to argue that the STEM acronym is problematic. Besides critiques that the acronym encompasses too many distinct and incomparable disciplines or ignores the arts and humanities, there also exist problems when "STEM" is used as a way to describe occupational groups. Most parties agree that there is no universally accepted way to define a STEM occupation or group of STEM occupations. In a report by the National Governor's Association, Thomasian (2011) notes, "No standard definition exists of what constitutes a STEM job, and different studies often use slightly different groupings" (p. 8), while the authors of a report prepared by the Chairman's Staff of the United States Congress Joint Economic Committee (2012) explain, "There is some disagreement with regard to precisely which degrees and occupations fall into the category of STEM" (p. 1). In recognition 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.[2]

Nonetheless, until a standardized understanding of STEM occupations is adopted, the status quo is problematic. Why? Because depending on how STEM occupations are categorized,

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

[2] The SOCPC is chaired by the U.S. Bureau of Labor Statistics and consists of members from other executive departments.

resulting analyses will vary considerably. The problem with this state of affairs is not strictly academic and theoretical. Instead, the stakes are very high for students and adult workers who are 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.

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.

Part 1: What *Exactly* Is a STEM Occupation?

In this section we discuss two issues that are central to the problem of the STEM acronym when discussing occupations: how occupations in general are classified and organized and how various 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.[3] 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.a). The SOC system is organized into occupational groups that become successively more detailed, from major groups (e.g., life, physical, and social science occupations 19-0000), minor groups (e.g., life scientists 19-1000), broad occupations (e.g., agricultural and food scientists 19-1010), and finally to the most fine-grained level of detailed occupations (animal scientists, 19-1011). The information provided by the BLS on its Occupational Employment Statistics (OES) website for detailed occupations such as animal scientists includes employment figures, current and projected wages, and the geographic distribution of jobs in the category.[4]

> The SOC organizes occupations in groups based on "similar job duties, and in some cases, skills, education and/or training."

[3] Developed in 1977, the SOC underwent revision in 2010, with additional changes planned for 2018.

[4] See http://www.bls.gov/oes/current/oes191011.htm.

Another system for classifying and organizing occupations is called O*Net. Developed by the Department of Labor, O*Net is 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, additional criteria are introduced whereby users can explore differences and similarities across occupations based on these other factors.[5] 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.[6]

> **Occupations Are NOT Industries**
>
> 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. Further, a worker in a particular occupation (e.g., electrical engineering) has the potential to work across multiple industries. O*Net responds to this distinction by allowing users to browse occupations WITHIN industries. Thus, when speaking about job and wage growth, as well as desirable educational pathways, speaking in terms of *occupations* instead of *industries* is preferred and more accurate.

Thus, a search on the O*Net system for animal scientists yields not only employment and wage estimates, but also information on criteria such as:

- tasks (e.g., communicating research findings to the scientific community)
- tools and technology (e.g., animal husbandry equipment, densitometers)
- knowledge (e.g., biology, chemistry, customer service)
- skills (e.g., reading comprehension, writing, science, critical thinking).

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[5] Although not incorporating every occupation found in the SOC system, when an SOC detailed occupation is directly adopted into O*Net, the occupation retains the SOC-designated numerical label and adds on ".00" to the end. If the occupation in O*Net is more detailed than the SOC, a decimal is added, such as ".01" and ".02" after the SOC-designated numerical label. For example, nuclear technicians (adopted directly from the SOC) are 19-4051.00. Detailed O*Net-SOC occupations within that occupation are nuclear equipment operation technicians labeled 19-4051**.01** and nuclear monitoring technicians labeled 19-4051**.02** (example is from the O*Net-SOC 2009 taxonomy; National Center for O*Net Development, 2010).

[6] The search criterion of "industry" in the O*Net system is worth noting, given the problematic nature of equating entire industrial sectors (e.g., manufacturing) with occupations (e.g., a detailed manufacturing job).

Further, O*Net provides comprehensive descriptions of occupations structured into six domains: worker characteristics, worker requirements, experience requirements, occupational requirements, workforce characteristics, and occupation-specific information. This Content Model is the "conceptual foundation of O*Net" that organizes key information about work (National Center for O*NET Development, n.d).

While most labor market researchers rely on the SOC system to classify occupations, the more comprehensive approach exemplified by O*Net is being increasingly used by researchers and policymakers in discussions about what types of training and education are required to succeed in certain types of occupations (e.g., Rothwell, 2013; Wisconsin Department of Workforce Development, 2014).

How STEM Occupations are Determined

Once occupations are classified, the next step for analysts interested in studying STEM is to determine which occupations or groups of occupations should be considered "STEM." This involves two decisions: (1) what types of criteria (e.g., nature of work performed, skills, education or degree field, knowledge, type of worker[7]) 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. One of the key findings from this analysis is that researchers and government agencies vary considerably on both of these counts, which results in a wide range of views regarding what constitutes a STEM occupation. In this section we review six distinct ways that STEM occupations have been defined in the field. See Table 1 for a summary of how each of the six agencies described in this section classify STEM occupations.

A Growing Focus on Skills, Not Tasks Performed, As a Way to Classify Occupations

On a national level, the O*Net system represents a growing trend to classify jobs on the basis of required skills and aptitudes, rather than solely based on tasks performed as is reflected in the BLS-SOC system.

In the state of Wisconsin, initiatives to develop "skills clusters," or groups of similar skillsets and aptitudes, are becoming more popular as some view the focus on a single skillset linked to a single occupation to be an overly narrow view. In *Be Bold 2:Growing Wisconsin's Talent Pool*, the authors argue that, "skills clusters are a contemporary way to group multiple occupations that share similar skills. Within the cluster, skills may be transferrable across occupations or with additional training may serve as a stepping stone to another position within the cluster. In the future, mobility across industry and roles will be a new normal, and will require that we look at workforce development as an ongoing and critical component of Wisconsin's talent strategy" (Competitive Wisconsin, 2012, p. 5).

This concept of skills and/or industrial clusters is being adopted by political figures in Wisconsin, as both leading candidates for the 2014 Governor's race have adopted the notion as central components of their economic development platform (Walker, 2013; Burke, 2014).

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[7] "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 occupations[g]
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

Bureau of Labor Statistics. All BLS publications reviewed for this analysis used the SOC system, which primarily classifies occupations into groups based on tasks performed in the workplace. Researchers at the BLS then selected a variety of occupations from the SOC system to create their own definitions of STEM occupations. In many cases, these occupations were drawn from three SOC major groups: architecture and engineering occupations; computer and mathematical occupations; and life, physical, and social science occupations. For example, in a 2007 BLS publication, the STEM occupational category consisted of natural science, mathematical science, engineering, and technology-related occupations (Terrell, 2007). In another instance, 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.

Standard Occupational Classification Policy Committee (SOCPC). Identifying the growing need for a standardized definition of STEM, in 2012 the Office of Management and Budget (OMB) asked the SOCPC to propose options for defining STEM occupations. The SOCPC formed a workgroup with representatives from seven agencies, and together they proposed options for what occupations should be deemed as “STEM.” They determined that STEM occupations consisted of occupations within two primary 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.

***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

Another set of distinctions was added by the SOCPC with the inclusion of five *types* of STEM occupations that exist 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” are organized according to the 2010 SOC system and include

184 detailed occupations (SOC Policy Committee, 2012). Thus, the new SOCPC-proposed system specifies certain SOC detailed occupations as core or related STEM occupations and also organizes them by type of occupation (e.g., technologist and technician). See Table 2 for the organizational scheme of the SOCPC's STEM occupations.

O*Net. The O*Net system provides a variety of ways to think about STEM as a group of occupations. While O*Net does not clearly specify what it means by a "STEM" job, two of the search functions available on the website shed light on its designers' thinking. Two ways that users can search for jobs are by the Career Cluster and STEM Discipline search functions. The STEM Career Cluster includes occupations involving "planning, managing, and providing scientific research and professional and technical services (e.g., physical science, social science, engineering)." This includes "laboratory and testing services and research and development services" (O*Net OnLine, n.d.b). Detailed occupations from 10 SOC major groups appear at least once in O*Net's STEM Career Cluster. Of those 10, detailed occupations from the usual 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. This search identifies occupations that "require education in science, technology, engineering, and mathematics (STEM) disciplines," specifically in chemistry, computer science, engineering, environmental science, geosciences, life sciences, mathematics, and physics/astronomy (O*Net OnLine, n.d.c). Together, all 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. Thus, O*Net organizes STEM occupations by Career Cluster, which groups occupations based on similarities in required skills within the same field of work and/or by STEM Discipline, which is organized by required education in eight STEM disciplines.

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 as determined by data from sources such as the NSF/National Center for Science and Engineering Statistics (NCSES)'s Scientists and Engineers Statistical Data System (SESTAT), data from the BLS' OES survey, and data from the U.S. Census Bureau's American Community Survey (ACS); (2) those holding a degree in an S&E field,[8] which is based on SESTAT data; and (3) whether or not a worker uses technical expertise at the bachelor's level in one or more S&E fields, which again comes from SESTAT data[9] (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.

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[8] This is an issue we address in Part 3.

[9] 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.

For example, 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 (e.g., technical writers) (NSB, 2014).

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 jury appears to be out on how these two domains differ.

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, although this distinction also appears to be unclear.

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 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

When considering the STEM workforce writ large, STEM 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).[10]

U.S. Government Accountability Office

The Government Accountability Office (GAO) provides research and evaluation services to the U.S. government, and in May of 2014 it issued a report on the relationship between education and the STEM workforce (U.S. GAO, 2014). In this report three different sub-fields of STEM jobs are described: Core STEM (e.g., engineering, life sciences, physical sciences), Healthcare STEM (e.g., health practitioners, health technologists), and Other STEM (e.g., architecture and related, social sciences, STEM teaching). In conducting its analysis, the GAO reported using the SOCPC recommendations for a standardized definition of STEM jobs and included any occupation in the SOCPC report classified as STEM (U.S. GAO, 2014, p. 41). The sub-groups of Core, Healthcare, and Other were based on options provided by the SOCPC for defining STEM occupations.

Center on Education and the Workforce at Georgetown University. The Center on Education and the Workforce (CEW) at Georgetown University is one of the more widely cited sources of labor market analysis in the STEM fields. In a report called *Help Wanted*, which focused on the educational attainment needed to acquire the jobs of the future, authors Carnevale, Smith, and Strohl (2010) defined STEM using detailed occupations within the following SOC major groups: computer and mathematical occupations, architecture and engineering occupations, and life, physical, and social science occupations. This report also included projections for the types of education and training required to get a STEM job in the future, which will be discussed in Part 3.

In another report called *STEM: Science, Technology, Engineering and Mathematics*, Carnevale, Smith, and Melton (2011) determined that STEM occupations include detailed occupations from the following SOC major groups: computer and mathematical occupations, architecture and engineering occupations, and life, physical, and social science occupations, although this particular analysis excluded the social sciences.[11]

These two reports published by the CEW indicate that even among researchers in a particular setting, approaches to defining STEM occupations can vary. But their definition of STEM, they argue, is more “encompassing than traditional definitions” (Carnevale et al., 2011, p. 6) because they include workers *at the sub-baccalaureate level*, as well as those working in technical occupations that require highly technical skills.

Brookings Institution (Rothwell, 2013). The Brookings Institution released a report (Rothwell, 2013) called *The Hidden STEM Economy*, which argues that a large number of STEM

[10] For the remainder of this paper, we will specify whether an occupation is S&E, S&E-related, or STEM when reporting specific data points from the NSF. These terms will not be used interchangeably when data is reported.

[11] This report is particularly interesting in its use of O*Net data to identify abilities, knowledge, skills, values, and interests associated with STEM occupations.

jobs go unnoticed due to the attention researchers and the media pay to occupations requiring a bachelor's degree or higher (a point reinforced by organizations such as the NSF and noted by researchers such as those at the CEW). He suggests that a variety of jobs may require some degree of STEM knowledge. In other words, Rothwell (2013) notes too much focus on white-collar jobs and a disregard for technical and blue-collar work (or what he calls "nonprofessional" occupations). In response, a new method for classifying what constitutes a STEM job is proposed.

Using O*Net knowledge scores in biology, chemistry, physics, computers and electronics, engineering and technology, and mathematics, Rothwell (2013) calculated *gradations* of STEM knowledge in occupations, and subsequently classified STEM occupations as either: (1) "High STEM in any one field," or (2) "Super-STEM" or "High-STEM across fields."[12] 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[13] or technical jobs in fields such as construction and production also frequently demand STEM knowledge" (Rothwell, 2013, p. 1).

In this report, 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. Ultimately, one of the primary contributions of Rothwell's work is the argument that the national dialogue over STEM occupations has improperly favored the professional occupations in ways that not only result in the undercounting of STEM jobs but also the denigration of blue-collar work that in fact requires significant knowledge of certain STEM disciplines.

Part 2: STEM Job Numbers and Wage Estimates

Next, we turn to an examination of 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. As previously noted, the influence is considerable and differences in which occupational types are considered STEM result in widely fluctuating figures.

A Cautionary Note: Challenges to Comparing Across Studies and Reports

Before presenting the results of our analysis, a cautionary note regarding the interpretation of the data presented here is important. When making estimates and projections of job numbers and wages, analysts often use different data sources from different years, which make direct comparisons between studies impossible in many cases. For example, reports draw on the following data sources to report occupational estimates: the OES from the BLS,[14] the Current Population Survey (CPS)

[12] We will use Super-STEM throughout to refer to this STEM category.

[13] Rothwell defines "blue collar" as 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 work (Rothwell, 2013, p. 7).

[14] Covers all full- and part-time wage and salary workers in nonfarm industries; does not cover self-employed, owners, and partners in unincorporated firms; household workers; or unpaid family workers (Bureau of Labor Statistics, n.d.b).

from the BLS,[15] the ACS from the U.S. Census Bureau,[16] or the SESTAT from the NSF/NCSES.[17] For example, occupational data obtained from the NSF and the Census Bureau surveys require individuals or household members to provide their own information about job titles and work activities, while the OES survey asks employers to classify their workers based on SOC definitions. The NSF notes, "Differences between employer- and individual-provided information can affect the content of occupational data" (NSB, 2014, p. 3-8). The SESTAT also only surveys individuals with a bachelor's degree or higher. Further, even the ways these organizations parse out occupations matters (e.g., according to NSB (2014), the SESTAT includes postsecondary teachers in S&E fields, while the ACS separates postsecondary teachers into a single occupational category regardless of field, so postsecondary teachers in S&E fields are not included in its analysis).

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. How is this variation possible?

Across the board, STEM job or S&E job number estimates range from 5.4 million to 26 million. How is this variation possible?

Consider an example from two organizations that categorize occupations based on the SOC system. In one analysis, Jones (2014) estimated that in 2013, according to the standardized definition of STEM developed by the SOCPC, there were almost 17 million workers in STEM jobs. In contrast, analyses by the NSF using its own definition of S&E occupations, estimated that about 5.9 million workers were in the S&E workforce just one year earlier (2012)—a mere one third of the estimate using the SOCPC's definition (NSB, 2014).

[15] Covers civilian noninstitutional population 16 years and older (Bureau of Labor Statistics, n.d.c).

[16] Covers U.S. population (United States Census Bureau, n.d).

[17] Covers individuals with bachelor's degree or higher in S&E or S&E-related field or with non-S&E bachelor's but working in S&E or S&E-related occupation (NSB, 2014).

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

	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)[x]	Above $50,000, less than a bachelor's degree Nearly $96,000, bachelor's degree and above (2011)[x]

[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

While there is one year separating the estimates, both agencies used the OES dataset for their estimates and they both used the SOC scheme. How can we explain this discrepancy? Part of this variation in job estimates is explained simply by noting which occupations are included in the analysis. The SOCPC analysis (Jones, 2014) includes individuals who work in health occupations, as well as individuals in relevant managerial, sales, and technician roles. In contrast, the NSF does not include workers in these positions when discussing S&E occupations. The variation noted here shows how much the categorization of occupations matters.

The data in Rothwell's (2013) report also demonstrate 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. The inclusion of blue-collar and technical occupations (because they, too, may require STEM knowledge) further boosts this job number estimate above the rest.

Estimating the size of the S&E workforce based on degree field has an enlarging 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. S&E degree fields include biological, agricultural, and environmental life sciences; computer and mathematical sciences; physical sciences; social sciences; and engineering, while S&E-related degree fields include health fields; science and math teacher education; technology and technical fields; architecture; and actuarial science (NSB, 2014). In fact, 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 (2010).

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. Projections about STEM jobs reveal a similar pattern to the "current" estimates from the previous section, 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. To illustrate this point, we offer examples of projections for STEM jobs from three different sources.[18]

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. Second, 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

[18] 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.

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 that 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. But again, these figures vary considerably depending on which occupations and types of workers, particularly blue- vs. white-collar jobs, are included in the analysis.

According to his analysis of the SOCPC's options for defining STEM jobs, Jones (2014) found that STEM workers (those in both core and related domains, which includes health occupations and types of occupations such as managerial, sales, technician/technologist, and postsecondary teaching) in 2013 earned almost $80,000 per year, which is almost 1.7 times the national annual average salary of $46,440. While STEM jobs are being touted as a desirable career goal for students and dislocated workers for several reasons, this wage premium is certainly one of the most attractive features for jobs in this area. But, drilling down into the numbers, 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)—data that illustrate both the range of wages available in STEM fields as well as the broad range of occupations that can be included in the category.

In contrast, the NSF identified workers earning a range of salaries (from over $74,000 to almost $83,000) depending on whether they were working in S&E occupations, STEM occupations, or S&E-related occupations in 2012 (NSB, 2014).[19] These estimates encompass the average STEM salary estimate from Jones' (2014) report, but the NSF adds more detail regarding the specific job classification in which the worker is employed (i.e., S&E, STEM, or S&E-related). When NSF used degree field as a measure of the S&E workforce (i.e., degree in S&E or S&E-related field at the bachelor's degree level or higher), different wages were estimated. The median annual salary for a worker in an S&E occupation and with his or her highest degree in an S&E field made about $78,000 in 2010, while the median annual earnings for a worker in an S&E-related occupation with a degree in an S&E field was $65,000 in 2010. The range of salaries was much larger for someone with a degree in an S&E field (about $13,000) than for a worker with a degree in an S&E-related field working either in an S&E occupation ($72,000) or an S&E-related occupation ($70,000) in 2010. This example shows again how the inclusion of certain occupations matter: S&E occupations do not include major fields like healthcare fields and technology and technical fields, while S&E-related occupations do.

[19] Note that these occupations include workers at all levels of education.

In their *STEM* report, the researchers at the CEW also estimated average annual earnings for STEM workers by occupational categories, with salaries ranging from $61,000 to $78,000 based on ACS data between 2005 and 2009 (Carnevale et al., 2011). This gives readers a more complete picture of how certain groups are paid relative to others. That is, engineers are clearly favored in terms of salary, as they make about $78,000 per year compared to architects, surveyors, and technicians who make about $61,000. Estimates provided in the *Help Wanted* report indicate that STEM workers, which in this case include those in social science occupations, made over $71,500 per year on average in 2008 according to the authors' analysis of CPS data (Carnevale et al., 2010). However, in this report, wages are broken out by educational attainment, with the STEM fields enjoying high earnings relative to all other fields except managerial and professional office positions. Wages were estimated for STEM workers with a master's degree or higher ($90,948), a bachelor's degree ($77,031), some college ($59,743), high school graduates ($55,179), and high school dropouts ($50,940) (Carnevale et al., 2010, p. 105).

A Closer Look at Healthcare

Including blue-collar jobs has obvious implications on the job number estimate (increases it) and the wage estimate (decreases it). What about the inclusion of healthcare—an occupation referred to as a "STEM competitor" by Carnevale et al. (2011)? According to the BLS Employment Projections, in 2012 there were over 8 million jobs in the SOC major group healthcare practitioners and technical occupations. This number is estimated to increase to over 9.7 million jobs by 2022, and almost half of the occupations projected to have the largest percentage increase between 2012 and 2022 are related to healthcare. The healthcare practitioners and technical occupations are projected to grow more than 21% between those years (Bureau of Labor Statistics, 2013a). The wages earned by workers in healthcare are also comparable to STEM occupations. According to the BLS' OES program, in 2013 workers in the healthcare practitioners and technical occupations jobs earned an average annual wage of over $74,000 (Bureau of Labor Statistics, 2013b).

Finally, in *The Hidden STEM Economy*, Rothwell's (2013) two definitions of STEM occupations (i.e., High STEM and Super-STEM) captured the largest 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 larger— 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.

The bottom line is this: Depending on how STEM occupations are categorized, the resulting estimates for current and future jobs, as well as expected earnings, will vary considerably. Essentially, 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.

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

Besides influencing job and wage figures, 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. Too often, the complexity involved in linking educational levels to workforce projections (using an overly ambiguous definition of STEM work) is glossed over in media reports and educational information that prospective students and their families use to make life-changing decisions.

As we point out below, 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. In this section we discuss the ways educational attainment has been operationalized and the implications these methods have for the resulting estimates of the types of education and training required to get a STEM job.

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. In the explicit category lies the NSF, where one way to measure the S&E workforce is by the field of the degree held by the individual. Again, according to the NSF, S&E degree fields include biological, agricultural, and environmental life sciences; computer and mathematical sciences; physical sciences; social sciences; and engineering, while S&E-related degree fields include health fields; science and math teacher education; technology and technical fields; architecture; and actuarial science (NSB, 2014). 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 exact 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. As previously noted, this view of STEM jobs omits a considerable number of occupations that do in fact require knowledge of STEM disciplines but may only require a certificate or associate degree. 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

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.

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. Additionally, Rothwell (2013) estimated that in 2011 36% of High STEM jobs and 28% of Super-STEM jobs existed for those with a postsecondary certificate or associate degree. Using the definition of STEM from researchers at the CEW, there were an estimated 16% of STEM jobs that required a postsecondary certificate or an associate degree, while analysis of the NSF's definition of S&E

occupations generated an estimate that 14% of S&E occupations required that same level of education in 2011.

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. use a combination of datasets to estimate the demand for different types of certificates and degrees relative to labor market demand through 2018. The authors 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. In the STEM fields, the difference in educational attainment on wages is significant, as earnings range from $50,940 for high school dropouts to $90,948 for workers with master's degrees or better (Carnevale et al., 2010).

It should also be pointed out that 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

While the amount of attention being paid to STEM in the workforce 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 precisely is being referred to?

These are critical questions to answer, because at the federal and state levels, 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), it is clear that 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 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 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.

Consider also the effect that a policymaker's pronouncements regarding STEM opportunities would have on a student if, instead of pointing to figures showing a standard wage of $36 per hour, she were pointing instead to figures showing a $16 per hour standard? The lack of clarity regarding what precisely is meant by a "STEM job" in various analyses masks very real disparities between different kinds of work opportunities in these fields and the types of education required to get one of these jobs.[20] As a result, policy recommendations for STEM

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[20] Other caveats to the notion that STEM jobs are universally abundant and available should also be noted. Both Rothwell (2013) and Carnevale, et al. (2010) demonstrate that STEM job opportunities are not uniform across the

education and training may vary depending on both the type of STEM job under consideration, and also the geographic location of a school, college, or company.

Thus, our primary recommendations to the field are:

1. When interpreting labor market data, do not make broad generalizations about "STEM jobs" or entire industries (e.g., manufacturing) without specifying the exact occupation (e.g., electrical engineering, front line factory work) 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) Use 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) or those that may not require a bachelor's degree (e.g., blue-collar occupations).

In addition, 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. For example, the evidence indicates that the so-called "soft" skills such as communication and conflict resolution are in high demand, not to mention intangibles that may lay outside the purview of educational programming or policymaking (e.g., work ethic) (see Pellegrino & Hilton, 2012). Perhaps most important, employers are clamoring for workers who not only have technical expertise in a particular area such as STEM, but also those who can use their technical knowledge to engage in abstract reasoning, problem-solving, and trouble-shooting. These aptitudes highlight the critical role that pedagogy plays in both educational programs and in-house corporate training.

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.

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United States, with large metropolitan areas such as San Jose, CA, and Washington, D.C., representing high concentrations of STEM jobs.

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