A CONCEPTUAL AND OPERATIONAL DEFINITION OF STEM FOR IOWA COMMUNITY COLLEGES

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Abstract

Over the past three decades, educators, employers, workforce analysts and elected officials have stated great concern over the decline in student performance and workforce supply in science, technology, engineering and math (STEM). While the term has produced millions of dollars in grants, research and programming, the concept of STEM remains ambiguous. Our research into the technical definitions of state, federal, and national not-for-profit agencies reveal that an objective definition of STEM is largely illusive. In order to develop a definition of STEM for the Iowa Department of Education, we developed a comprehensive, conceptual definition of STEM that reflected the purpose and value of STEM stated in existing literature. We propose an integrated STEM model which stresses the role of science, technology, engineering, and mathematics have on each other. That concept is consistent with the interdependent advancement of science and technology. Following our conceptual definition, we developed an evaluating methodology for the selection of Codes of Instructional Practice (CIPs) for STEM at Iowa's community colleges. Our data revealed that the gender gap in STEM is applicable to Iowa. More positively, our data suggests that Iowa has a proportionate number of blacks and Hispanics enrolled in STEM, relative to Iowa's demographics. We found some programs drew high proportions of females, relative to total enrollment.

1. Introduction

As the United States approached the new millennium, America was quietly confronted with the looming issues surrounding the educational, economic and technological advancements of developing nations and growing concern regarding America's relative position as the center for innovation and intellectual capital in the next century. Over the past ten years, the United States has identified numerous areas for improvement to retain our innovative edge these programs fall under the conceptual umbrella of science, technology, engineering and math (STEM). However, to properly measure STEM programs, we need to the similarities and differences the technical definitions for reporting amongst the various institutional stakeholders.

We find that STEM has been defined differently by national organizations and across states. Some definitions seem to simply recapture math and science curriculum into STEM, while others cast a wider, more inclusive net. The Iowa Department of Education proposes an integrative STEM model which emphasizes the interplay between math, science, engineering, engineering technology, and technology. We find that females are less likely to participate in these programs at Iowa community colleges while minorities are proportionally represented.

Section 2 will give an overview on the need for STEM education; section 3 will review the disperse definitions of STEM across the United States; section 4 develops a conceptual model of STEM; section 5 demonstrates how the Iowa Department of Education translated the conceptual model into a list of STEM programs; section 6 analyzes the proportion of women and minorities majoring in STEM majors at Iowa community colleges; and section 7 concludes.

2. Challenges Confronting the United States

In reviewing the issues confronting America, we shall follow a logical progression along the "STEM Pipeline". The logic of the pipeline is that problems have a genesis that tends to build and magnify subsequent problems. In essence, inputs and activities are reflected in outputs, both positive and negative. For example, if American students are failing to achieve basic and proficient scores on math and science at the primary level, then it would logically follow that they will continue to fall behind at the secondary and post-secondary levels, as well. Further, without an advanced education, it is impossible to fill the demand for an educated STEM workforce. Each of these problems is interconnected and is being addressed by STEM initiatives. However, before we can discuss the solution (STEM), we must fully understand the problem from which it arose and how that influences our conceptual understanding of STEM.

Our challenges in math and science appear to originate at the primary and secondary level. The governing body of the National Science Foundation (NSF), the National Science Board (2007) found that the United States student achievement-levels in math and science are not competitive compared to their international peers. In 2003, the Program for International Student Assessment (PISA), an international test measuring STEM critical thinking skills, ranked U.S. students 19^{th} out of 29 nations; placing U.S. students beneath countries like New Zealand, Hungary and the Slovak Republic. They further found that nearly 30 percent of U.S. college students required remedial math and sciences courses in their first year of college. Similar results were found by the 2003 International Mathematics and Science Study (TIMSS). According to Kuenzi (2008) American students, while outscoring the international average in math and science, still scored lower in composite scores than: Singapore, the United Kingdom, Netherlands, South Korea, Japan, Hungary, Hong Kong, Estonia, and Chinese Taipei.

Combined, it is evident that the average American student remains academically uncompetitive compared to their international peers in math and science and nearly one third of students are unprepared to accomplish post-secondary math and science coursework. Given the disproportionate access to financial and physical resources of American students compared to their international peers, the shortcoming are even more confounding.

If we take a step back and analyze how American students are performing according to our own benchmarks, we find similar shortcomings. According to Kuenzi (2008) many American students are not even at basic levels, much less proficient in math skills. According to the National Assessment of Educational Progress (NAEP) the percentages of fourth grade students' at basic or proficient levels in math have increased between 1990 and 2005, the same cannot be said for their 8th and 12th grade counterparts. While proficiency in math skills among 8th graders has increased, basic skill levels have remained unchanged over the same time period. Twelfth grade tests results have actually declined since 1990, with fewer students scoring as either proficient or basic in their math skills. In addition, they found anywhere from 10 to 35 percent of all American students score under the basic skill-level in math. In 2005, nearly a third of all students tested below basic skill levels in math. In essence, a significant portion of American students are failing to achieve the standards set by American educators, much less remain competitive with their international peers.

If form follows function, then we have to question the manner in which students are being taught. Not surprisingly, studies have shown that a significant number of American math and science teachers are not qualified in the areas they teach. According to the Governor's Association (2007) wage disparities between the public education and private sector have contributed to the overall issue of attrition and the disparity of qualified math and science teachers in urban schools in comparison on suburban schools. This has resulted in a profession where teacher qualifications pose an obstacle to meaningful STEM advancement. One cannot reasonably expect students to learn advanced math and science knowledge and skills from educators who do not feel themselves equipped to teach those subjects. The Governor's Association states that "40 percent of U.S. middle-school physical science teachers teach out of their field, about 20 percent of middle-school biology teachers teach outside of their field," further, "eighth grade American math and science teachers were less likely to specialize (i.e., have either an undergraduate major or master's degree) in their STEM subject areas than their counterparts in other countries" and "that only one-quarter of sixth through eighth grade out-of-field math teachers felt, by their own assessment, well prepared to teach a basic set of arithmetic topics." (pg. 9).

Quantitatively, the actual number of science and math teachers is much lower than the levels needed. The Business-Higher Education Forum (2007), states "that the United States will need more than 280,000 new mathematics and science teachers by 2015 (pg. 9). Schools with high minority and high-poverty students are anticipated to have the greatest need. Students in these schools are significantly more likely to have math teachers that neither majored nor minored in the subject. Additionally, retention of qualified teachers within the profession remains a serious and persistent issue. The forum found that "approximately half of all teachers leave within five years of entering the profession" (pg 10); further, math teachers possess the highest turnover rate amongst K-12 teaching professionals with science teachers holding second place (pg. 15). Retention rates are even lower in lower-income districts, where the rate of attrition is half again higher than higher-income areas (pg. 10). Further issues exasperate the problems in K-12 math and science, including: more than a third of America's teachers will have retired between 2007 and 2010, replacement of these teaching professionals remains the lowest of all teaching sub-fields, and anticipated growth in the of the American students over the next two decades increasing the demand for math and science teachers (pg. 14)

Research into the use and quality of secondary science labs reveal a number of issues. The Ewing Marion Kauffman Foundation (2007) reported "science labs in the Kansas City Region do not meet national standards and much work needs to be done to bring the science labs up to the national standards" (pg. 5). In their survey of 170 schools within the Greater Kansas City region, the Foundation found that safety standards were not being upheld in the majority of school science labs; that the majority of science labs were not large enough to allow for productive learning; equipment in many science labs were often unused, antiquated or broken; science class sizes were too large and exceeded recommended student-teacher ratios; most students received less than 2/3rd's the recommended science lab time, per week; science labs were "rarely incorporated into the overall science curriculum" (pg. 6); and that there were no guidelines or policies within school districts on the proper use of science labs for science teachers. They further conclude that while studies of science labs are not common, studies conducted by the

National Research Council and the University of Texas found similar problems to those in Kansas City.

The Kauffman Foundation further contends that students and parents are not motivated to promote the changes necessary to enact meaningful STEM reform. They explained that employers within the Kansas City region expressed great concerned about the math and science skills of their younger employees. Many felt that their skills were not rigorous enough to meet the innovative needs of their business. The Foundation further found that parents and students in the region did not reflect similar concerns. They suggested that while both parents and students believed science and math are important to society, the students did not feel that either subject was necessary for their personal success. Further, parents did not feel that improvement in math and science education was a priority within their area. This disconnect between parents, students, and employers is troubling for it reveals that those with the greatest voice in local education (local parents and residential taxpayers) are not motivated to address the mounting issues regarding STEM. While we cannot generalize that the situation within Kansas City region is universal for the entire nation, public and academic sentiment would suggest that the issues confronting Kansas City are typical for many communities within the United States. (Kadlec & Friedman, 2007)

At the post-secondary level, studies have exhibited a general growth in STEM bachelor’s degrees but have also shown a steep decline in master’s and doctoral STEM degrees and demonstrated a loss of the highest-performing students in the STEM pipeline. According to the U.S. Government Accountability Office (2005) there has been an overall increase in the number of students entering STEM fields, although these increases are in specific subfields of STEM; whereas there has been a considerable decline in other subfields. Overall growth in STEM enrollment across all non-associate, postsecondary degree programs was 20.74% between 1995-1996 and 2003-2004 Academic years. When accounting for population growth between 1995 and 2003, the assertion of STEM enrollment growth is proven accurate. According the U.S. Census Bureau's historical national population estimates (2000) and national and state population estimates (2005), roughly 1.04 percent of Americans enrolled in a STEM major in 1995 while 1.19 percent enrolled in 2003. While overall STEM graduates may have increased, a specific breakdown reveals declines in many STEM-associated subfields at the master and doctoral levels. Between 1995 and 2003, they found declines in STEM Master's degree graduates in the following subfields: biological/agricultural science by 41 percent; Earth, atmospheric, and ocean sciences by 8 percent; Engineering by 11 percent; physical sciences by 14 percent; and Technology by 44 percent. Similar results were found in Doctoral graduates in the following subfields: biological/agricultural science by 53 percent; Earth, atmospheric, and ocean sciences by 29 percent; Engineering by 18 percent; Math and computer sciences by 14%; physical sciences by 15 percent; and Technology by 74 percent. These percentages suggest a significant decline in students graduating with STEM doctoral degrees (GAO, 2005, pg. 24). These results are mirrored by Lowell, Salzman, Bernstein, & Henderson (2009), stating:

> "It appears that the 1990's marked a turning point in longer-term trends for the best students either in high school or college. The top quintile SAT/ACT and GPA performers appear to have been dropping out of the STEM pipeline at a

> substantial rate, and this declines seems to have come on quite suddenly in the mid-to-late 1990's" (pg. iii).

Both findings suggest that America's best and brightest, those whom we count on for innovation and revolutionary ideas, are not demonstrating an interest in STEM and are instead moving into other subfields.

These findings are further demonstrated in the "STEM Pipeline" meaning "of those who become involved in STEM programs, how many are continuing STEM studies at the postsecondary level, persisting with their studies, achieving a degree and entering the STEM workforce?" According to Chen & Weko (2009) the quantitative-correlative support for STEM program effectiveness in equity may be questionable as their research found that the established indicators and correlations for student success were similar for successful movement through the STEM Pipeline. They found that "in general, the percentage of students entering STEM fields was higher among male students, younger and dependent students, Asian/Pacific Islander students, foreign students or those who spoke a language other than English as a child, and students with more advantaged family background characteristics and strong academic preparation than among counterparts who did not have these characteristics." (pg. 17). They further found that students with these characteristics were more likely to persist in a STEM major and acquire their degree, completing the pipeline. They also found that nearly 47 percent of all STEM entrants either switched to a non-STEM area of study or failed to acquire a degree (pg. 18).

This trend is not reflected internationally. As the United States is facing a decline in STEM talent, the rest of the world is surging ahead. Friedman (2005) states:

> “that of the 2.8 million first university degrees (what we call bachelor’s degrees) in science and engineering granted worldwide in 2003, 1.2 million were earned by Asian students and Asian universities, 830,000 were granted in Europe, and 400,000 in the United States. In engineering specifically, universities in Asian countries now produce eight times as many bachelor’s degrees as the United States” (pg. 257)

This is particularly relevant to our economy as performance in high school math and science correlates to higher wage earnings later in life. According to Joensen & Nielson (2009) found that students who take higher-level math courses had an average wage 25-30% higher than students that did not. While Joensen & Nielsen acknowledge that the students who pursue higher-level math tend to have similar demographic characteristics, they do conclude that there is “a positive causal impact on math and earnings” (pg. 198). Past research supports conclusions from the previous studies. If there is a definite correlation between wages and skills in math and science, it is certainly in the interest of all to encourage higher performance in these areas. From a financial perspective, growth would be intimately tied to a skilled labor force in these areas.

As the number of advanced STEM graduates has declined, concern about America’s supply of workers for the STEM workforce have grown. Over the past 60 years, the United States has shifted from an industrial economy, requiring skills in routine, manual tasks to an information, service-based economy driven by technology that requires non-routine, interactive tasks and skills. It is estimated that by 2014, 75 percent of the fastest growing occupations will require significant training in math and science (State Educational Technology Directors Association, 2008). According to Butz, Kelly, Adamson, Bloom, Fossum & Gross (2004) “The implications of a shortage of skills critical to U.S. growth, competitiveness, and security are serious, probably more so now than in recent decades, as are the implications of continuing low entry of female and minority students into many STEM fields” (pg. 10).

The issue of gender and racial inequity continue to plague the STEM workforce. According to the public-private partnership BEST, Building Engineering & Science Talent (2008), in 1999 “despite decades of effort to broaden its base, the U.S. science and engineering workforce remains about 75 percent male and 80 percent white. Women, African Americans, Hispanics, Native Americans and persons of disabilities – the “underrepresented majority” that makes up *two-thirds* of the entire U.S. workforce – *account for only 25 percent of the technical workforce*” (pg. 2). In failing to create a diverse STEM workforce, the United States limits itself to the ideas promoted from a homogenous workforce and a homogenous work culture that may be less apt to conceive of revolutionary ideas.

In the end and as we first discussed, the backdrop for America’s focus on STEM is the emergence of a new, world economy that is not necessarily dominated by the United States, but rather centered around developing nations competing for global human, organizational and financial capital; specifically the world’s major population centers, China and India. The urgency surrounding STEM was addressed by Thomas Friedman in his popular book *The World Is Flat*. In his writing, Friedman (2005) quotes the president of the American Association for the Advancement of Science, Shirley Ann Jackson; she effectively summarizes America’s anxiety about our place in the emerging world economy:

> "The U.S. is still the leading engine for innovation in the world. It has the best graduate programs, the best scientific infrastructure, and the capital markets to exploit it. But there is a quiet crisis in U.S. science and technology that we have to wake up to. The U.S. today is in a truly global environment, and those competitor countries are not only wide awake, they are running a marathon while we are running sprints. If left unchecked, this could challenge our preeminence and capacity to innovate." (pg. 253)

The mounting problems related to STEM are evident in the largest economy in the United States, the State of California. According to Offenstein & Shulock (2009) California, the world's eighth largest economy[3], owes much of its growth to its higher-than-average number of STEM occupations. While the state has enjoyed higher numbers of entrepreneurs, venture capital investment, independent patents and broadband deployment; they have conversely suffered from low use of technology within schools, education amongst immigrants, and has one of the lowest rates of bachelor degrees conferred amongst states with "new" economies (pg. 3). The California Secretary of Labor found that nearly half of all STEM occupations are anticipated to have shortages in the coming years. California is expected to average 46,100 STEM job openings between now and 2016; more than half of these openings will require at least a bachelor's degree (pg. 7). However, the growth in STEM degrees granted is not anticipated to meet the growing need for STEM workers. Furthermore, the current fiscal problems plaguing the State of California are expected to negatively impact the capacity of California's public universities and community colleges to produce STEM graduates. STEM degrees

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[3] Imputed based on World Bank (2009) estimates of country GDP and Bureau of Economic Analysis (2009) state estimates.

typically require intensive lab work and technical equipment that is more expensive than the inputs required for non-STEM majors. As budgets are reduced for education at the state-level, it is highly likely STEM inputs will be reduced, further exasperating the STEM problems in California. Not only this, but as the job outlook within the state diminishes, the likelihood of students enrolling in STEM and subsequently seeking employment will decline, as well; further exasperating California's attempt to bounce back from the current recession.

3. The Undefined Solution to Defined Problems: STEM

While our assessment of science and math appear overly pessimistic and critical, it is necessary for us to understand the problem so that we can sufficiently move towards a solution. The solution to all of the aforementioned problems has been identified as STEM by a variety of sources. With this proposal, money has followed. Between the grants of the National Science Foundation and the U.S. Department of Education, over $480 million dollars were spent on STEM, in 2006, alone (National Science Board, 2007).

So what is STEM? Simply, STEM is an acronym for science, technology, engineering and math. However, such a definition does not properly address what STEM is, precisely. Grammar offers little insight. Given the varying uses in both technical literature and mainstream conversation, it is impossible to identify whether STEM would be considered a noun or a noun modifier. Is it just STEM or is it STEM education? Some might call this semantics, but the fact remains that if STEM is an important focus of the American education system, we should be able to linguistically fence the word. Failing a linguistic attempt of a definition, we are forced to examine STEM from a conceptual approach.

The conceptual views of STEM are quite diverse. Many believe that STEM is any one of the disciplines within the acronym, science, technology, engineering and math or conjunction of the four subfields. Others contend that it is an entirely new discipline that integrates knowledge and skills from other education studies. Some assert that STEM is transdisciplinary and multi-faceted (National Science Teachers Association, 2009). This leaves us without even a conceptual consensus of STEM.

Much of the confusion regarding STEM can attributed to its evolving use and growing popularity. The most recent developments and variations of STEM are difficult to organize, and the history of STEM is not often referenced in peer-reviewed journals or publications; however, we have been able to assemble a history of STEM, chronicling major developments.

Policy discussion regarding science, technology, engineering and math has been prevalent since the earliest days of the Cold War. This focus for educational excellence in the name of national defense appears to have been the early motivator for investment in what would have then been considered STEM-related programs.

According to Sanders (2009), STEM's predecessor, SMET originated in the 1990's within NSF to encompass the understanding of science, math, engineering and technology, but remained largely unknown to the greater public.

The origin of the STEM acronym was explained to us in an electronic communication by Neeraj P. Gorkhaly, Research Associate at the Committee for Science, Engineering and Public Policy; he stated that when Rita Colwell became the Director of the National

Science Foundation in 2003, she re-arranged SMET into STEM, a more attractive acronym. This change was symbolically reflected when the former *Journal of SMET Education* changed their title to *Journal of STEM Education* in their volume 4, issue 3 publication. The journal stated "Please note that we have renamed the journal (from the Journal of SMET Education) to reflect a change in usage by the National Science Foundation, which has adopted the term "STEM" to emphasize that the focus needs to be on science, technology, engineering and math." (Raju & Sankar, 2003, pg. 2)

According to Sanders (2009) even after the 2003 change from SMET to STEM, many in the academic and administrative world were unfamiliar with the concept. The concept was popularized by Friedman (2005), which discussed the issue of an ascending and technologically-skilled India and China and the threat they pose to American preeminence in the math and science; keys to our status as an economic superpower. His book generated public discussion and galvanized institutional interest and government engagement on STEM issues which was only enhanced by the National Science Board's 2007 publication of *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Funding shortly followed, and as Sander's (2009) coined, "STEMmania" has ensued. This has left us with an almost completely decentralized understanding of STEM, largely leaving local agencies to assume the initiative. STEM has functionally become a series of different public initiatives to address a series social problems deemed solvable by more comprehensive achievement and promotion of science, technology, engineering and math.

Approaches in implementing STEM vary greatly. Some agencies are taking a comprehensive, multi-institutional approach to devising their STEM programs.

(Minnesota Department of Education, 2006). Meanwhile, other institutions do not possess the resources to generate STEM programming or have very limited resources or a specific purpose which extends to only a limited aspect of STEM. Casual surveying suggests that STEM programming is largely created and managed by primary, secondary and post-secondary institutions in most states. However, some state, federal and not-for-profit agencies have devised STEM definitions that can track the graduation and enrollment data of education institutions.

One of the major issues confronting STEM is data reporting and longitudinal tracking. The National Center for Education Statistics (2009) has focused on undergraduate student progress through the STEM pipeline in an attempt to understand the demographics of students entering STEM majors, the retention of students in STEM majors and the successful completion of those students in STEM majors. To date, their research results support the findings of other agencies cited earlier in our discussion.

STEM has also been recognized as an educational pathway to achieve the goal of a new green economy, connecting environmental concerns and problem-solving with science, technology, engineering and math (Arnett, Kozlowski, Peach & Valera, 2009). According to White & Walsh (2008), “New energy technologies will depend on a workforce that is prepared and trained to build and implement them. But the skilled workers for these industries will not emerge from a vacuum.” (page 9) This has resulted in some Workforce Development agencies becoming involved in STEM definitions and tracking.

Another facet of STEM concerns the issue social equity as we discussed earlier. Given the repeated statistical evidence that the typical STEM major is fairly homogenous, a number of initiatives have focused on creating a more diverse STEM population. Organizations like the STEM Equity Pipeline have been leaders in program and resource development to draw women and minorities into STEM fields.

The federal government has dedicated funding necessary to address many of these issues. In their 2006 report the GAO (2006) stated that $2.8 billion was appropriated in fiscal year 2004 for over 200 STEM programs. Most of these programs were in the form of financial aid for students or institutional grants to support infrastructure at colleges and universities. They further note that approximately half of these organizations have been or will be evaluated but the nature of that evaluation was not provided. They also acknowledged a limited degree of coordination between programs. While much of this data is now outdated and reflect trends between the mid-nineties and 2006, the data suggests that STEM initiatives have had mixed results or have not been evaluated for effectiveness. Of the results available during this period, employment in math and science related industries increased, but minimal change in technology and engineering was recorded. Demographically, there has been an increase in female enrollment and a subsequent decrease in male enrollment. However, minorities saw little change and males continue to represent the majority of overall STEM majors. The report further states that while STEM jobs have increased from 7.2 million to 8.9 million between 1994 and 2003, the majority of these jobs were in the computer sciences field, which strongly correlate to the growth in personal computer and internet use and do not necessarily reflect overall increases in engineering and technology. The report concludes that teacher performance and quality in STEM studies at the K-12 level continues to be problematic for generating interest and skills in all students. Regarding women and minorities, the report suggests that mentors and role models are needed to attract students to these fields.

Even with these results, we must question the external validity of these results. Did STEM programming result in the demonstrated, positive changes or were other confounding variables responsible? We can only answer this question through evaluation using the experimental method and this requires data measurement, analysis and reporting using consistent, solid technical definitions based on a stated, conceptual understanding.

4. Defining STEM in Iowa

During the 2009 legislative session, the Iowa State Legislature required the Iowa Department of Education and State of Iowa Board of Regents to report the proportion of women and minorities participating in STEM-related activities(Iowa Code Ch. 261E, § 3J). While the legislature mandated reporting, they did not provide a precise definition of STEM. In order to best comply with this mandate; we conducted academic research and institutional surveying of surrounding Midwestern states, national institutions and nonprofits in an attempt to discover the popular understanding of STEM.

The first phase of our research involved a review of the existing body of literature on STEM programs and STEM education. This review informed our understanding of the history and purpose of STEM initiatives. Much of this information was presented in the prior sections of this paper.

The second phase of our research involved collecting the technical definitions of STEM from various institutions that publish quantitative data. Iowa uses the

Certification of Instructional Programs (CIPs) codes for its data tracking and reporting. CIP codes are a taxonomic scheme created in 1980, by the National Center for Education Statistics. CIP codes are useful for applying objective designations of educational subjects and quantifying them for data tracking, reporting and analysis (National Center for Education Statistics, 2000). For the sake of applicability, we were primarily interested in programs utilizing (CIPs) codes.

To collect institutional definitions and gain a broad understanding of state, regional, and national definitions of STEM; definitions were collected from available, published sources from these institutions. In the event definitions were not easily assessable, the Iowa Department of Education conducted informal, electronic surveys of those organizations. Table 1 shows the following agencies and institutions were reviewed or contacted.

Table 1
Agencies compared by the Iowa Department of Education

Regional Agencies	Federal Agencies	National Not-for –Profits
• Iowa Public Universities Board of Regents • Iowa Department of Workforce Development • Iowa Community Colleges • Minnesota Department of Education • Minnesota Office of Higher Education • Minnesota State Colleges and Universities • Wisconsin Department of Education • Wisconsin Department of Public Instruction • Wisconsin Department of Workforce Development • Wisconsin Technical College System • University of Wisconsin System • Illinois Board of Education • Missouri Department of Higher Education • Ewing Marion Kauffman Foundation • Kansas Academy of Math and Science • Kansas Department of Education • Kansas Board of Regents • Nebraska Department of Education • South Dakota Department of Education • North Dakota University System • North Dakota State University	• National Science Foundation (NSF) • National Center for Education Statistics (NCES) • Committee on Science, Engineering, and Public Policy (COSEPUP)	• STEM Equity Pipeline • STEM Education Coalition

Note: Not all agencies had a technical definition of STEM. See Appendix A for a list of programs by agency.

A great deal of information regarding STEM was provided by many of these sources. However, among the institutions that either had published or responded to our surveys, ten were viewed as having the technical definitions of STEM that were desired for our comparative analysis.

The 11 institutions selected for our comparative analysis were: The National Science Foundation; Iowa Board of Regents; STEM Equity Pipeline; Iowa Community Colleges;

Iowa Workforce Development; National Center for Education Statistics; Minnesota Department of Education; University of Wisconsin System; Missouri Department of Higher Education and Minnesota State Colleges and Universities.[4]

When all STEM CIPs from the selected institutions were compared amongst each other, it was concluded that there was only a limited degree of consensus amongst institutions as to what defines STEM. Of the 1,848 CIPs found in the 2000 CIP Guidebook, 897 of them were considered to be STEM by at least one institution. Of the 50 two-digit CIP groups, 30 groups were considered STEM by at least one institution. Varying degrees of consensus were found amongst either individual CIP codes or groups but no two institutions had identical, overall definitions of STEM. However, the greatest degree of consensus centered on the following CIP groups: 1.00 Agriculture, 11.00 Computer and Information Sciences, 14.00 Engineering, 15.00 Engineering Technology and Technicians, 26.00 Biological and Biomedical Sciences, 27.00 Mathematics and Statistics, and 40.00 Physical Sciences. Consistency on individual CIPs was less evident as some institutions chose to include entire CIP groups in their definitions, others chose to include whole CIP sub-groups and others chose to select only individual CIPs amongst CIP groups and/or subgroups.

In discovering the lack of consensus amongst external institutions, we chose to develop our own methodology for creating a definition of STEM.

Our first objective was to create a conceptual understanding of STEM. While we originally approached the concept from the "sum of the four fields" perspective, a number of statements within the literature and conversations with professionals led us to

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[4] A list of CIPs for each agency is available in Appendix A.

consider STEM as being something other than a series of categories or subjects, but rather as a living process that incorporates history, evolution, innovation and change.

Philosophers in the area of science and technology have best articulated the interplay of science and technology. Namely, science and technology depend on each other with support from engineering and the tools of mathematics to progress. In the last century, research within science and research within technology have become practically indistinguishable. Science and technology both depend on mathematics as the formal language to discuss each discipline. Engineering wraps these concepts into implementation. We argue that the interdependent progress of science and technology needs to be emphasized in the definition of STEM.

Scientists often refer to replicable experiments as the defining characteristic of science. While important, a more important facet is of falsification. Generally, empiricism is crucial to the epistemological advancement within science. Specifically, Popper's (1959) formulation of falsification, though controversial in some areas of education, suggests the reason science is successful is the ability to discard inaccurate theories and retain those that have withstood significant testing.

Scientists use mathematics to express their findings and communicate to other scientists. Mathematical formulations assists replicability since it provides people with a precise expectation in the laboratory. Those formulations can also be used to make deductions on deeper, unobserved aspects of science, such as the exploration of the Higgs boson. Today it may be difficult for students to distinguish mathematics and science. Yet, the experiments of Michael Faraday and the formulations of James Maxwell provide an example distinguishing science and mathematics. Faraday, a scientist with little formal training, was able to suggest physical relationships, notably between electricity and magnetism, through raw experimentation. However, it left some to be desired since he was not able to express it in formal mathematics as commonly done in the early 19th century. James Maxwell, trained in mathematics, formulated many of Faraday's most important experiments through four questions, known as the Maxwell Equations.

A scientist's principal concern is empirical fact, which is derived through method and testing. Engineers must consider pragmatic issues related to scientific discovery. Namely, when science is translated into technology, the engineer must consider the functional requirements related to the device's operation. Engineering bring science into operations through processes that are different than the scientific process. First, the device(s) are conceptualized by drafting a conceptual sketch or computer model, such as CAD. Then the device(s) are tested by manufacturing a prototype.

Franssen, Lokhorst, van de Poel (2009) contend the manufacturing process is not considered as "design", but the process "is often reflected in the functional requirements of a device." For our purposes, we ultimately rejected many manufacturing-specific programs as STEM for this reason. However, we consider the maintenance of the manufacturing process as STEM. Individuals who service equipment designed by engineers are equipped with complimentary training to the engineers themselves. Community colleges tend to serve this area of the workforce—the occupations which fix devices created by engineers. For instance, HVAC occupations must know the scientific principles which funnel air efficiently around a structure. We refer to this component of engineering as engineering technology whose principal focus is to maintain and operate technology created by engineers.

Our final obstacle is to define the technology component of STEM. Technology can be interpreted widely. Modern technology must meet four criteria, it is: scientifically derived, contain a concrete component to count as technology (e.g., circuit board); must enter into some set of praxes which humans can use; a relation between the technologies and the humans who use, design, make, or modify the technologies in question (Ihde, 1993). In addition, we focus on technology that can be manipulated to advance and test science, math, and engineering. This last component narrows technology to that which is specific to STEM and not the generally used modern technology in the current economy.

Therefore, out conceptual model of STEM, shown in figure 1, has four components: science; math; engineering; engineering technology; and technology. We focus on the overlapping components of science, technology, engineering, and mathematics which reinforce each other. Thus, we do not consider some mathematical-based disciplines, such as actuarial science, as STEM. For example, actuaries do not practice mathematics to compliment science or to advance engineering.

This model fits within the history of science. Early science was able to exist independently from modern technology. However, science—with the use of mathematics—led some to design technology, which was in turn used to advance science. Presently, science could not advance without using technology that was created from earlier scientific discoveries. Quite simply, it's hard to imagine any science in the last century that could exist without the availability of electricity. Figure 2 shows a specific example of how Faraday's experimentation and Maxwell's formulation led to advancements in engineering and technology which led to further advancements in modern computing.

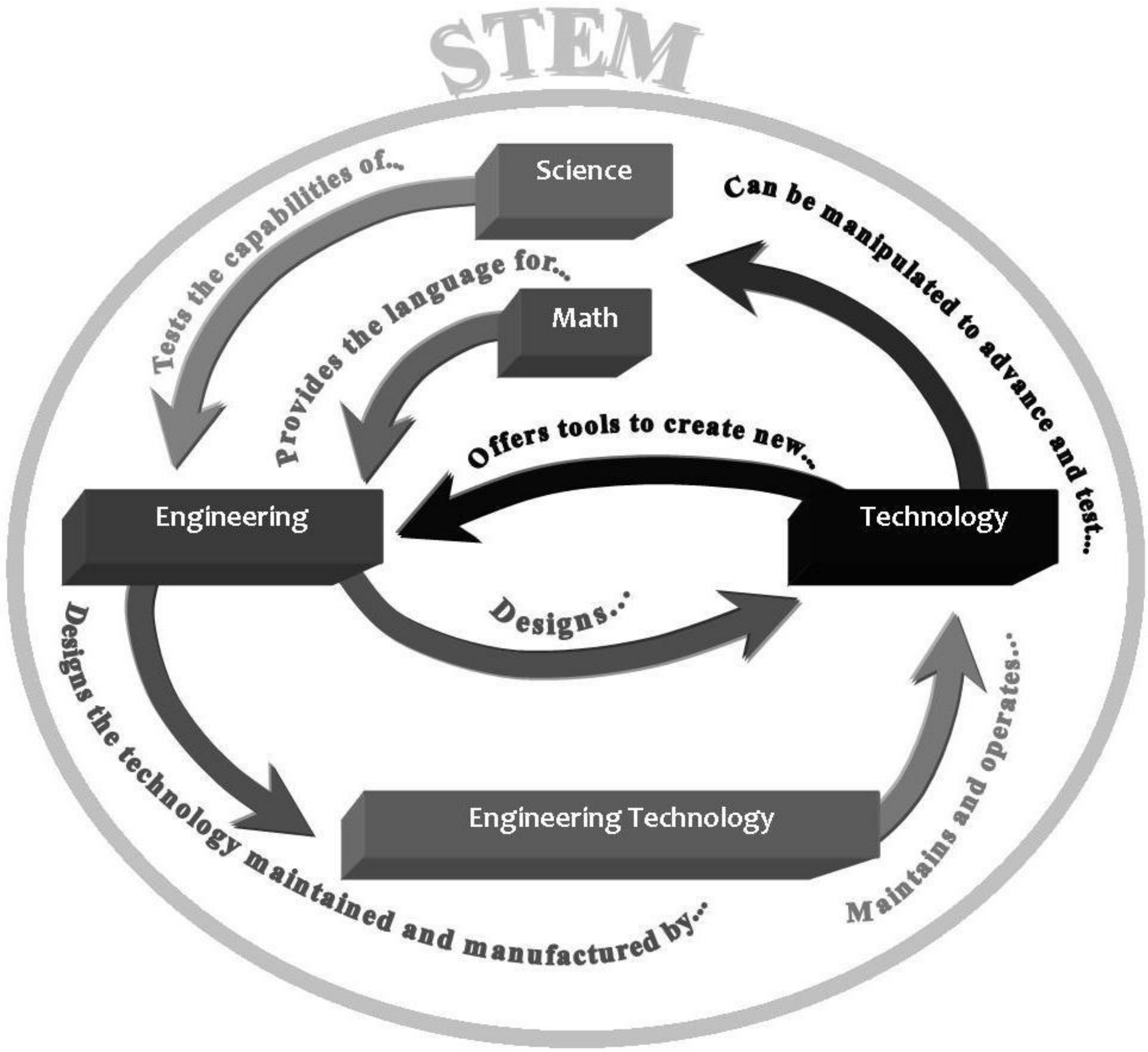
We also gave pause to the following statements provided in the National Academy of Sciences (2007) report *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. "Our economy depends on the knowledge that fuels the growth of business and plants the seeds of new industries, which in turn provides rewarding employment for commensurately educated workers" (National Academy of Sciences, 2007, pg 37); and:

> "The visible products of research, however, are made possible by a large enterprise mostly hidden from public view—fundamental and applied research, an intensively trained workforce, and a national infrastructure that provides risk capital to support the nation's science and engineering innovation enterprise. All that activity, and its sustaining public support, fuels the steady flow of knowledge and provides the mechanism for converting information into the products and services that create jobs and improve the quality of modern life. Maintaining that vast and complex enterprise during an age of competition and globalization is challenging, but it is essential to the future of the United States." (National Academy of Sciences, 2007, pg 42-43)

Given these statements, we surmised that if the inputs of STEM are funding and knowledge and its long-term outputs are economic growth and prosperity, then it is more appropriate to view STEM as a process, not a subject.

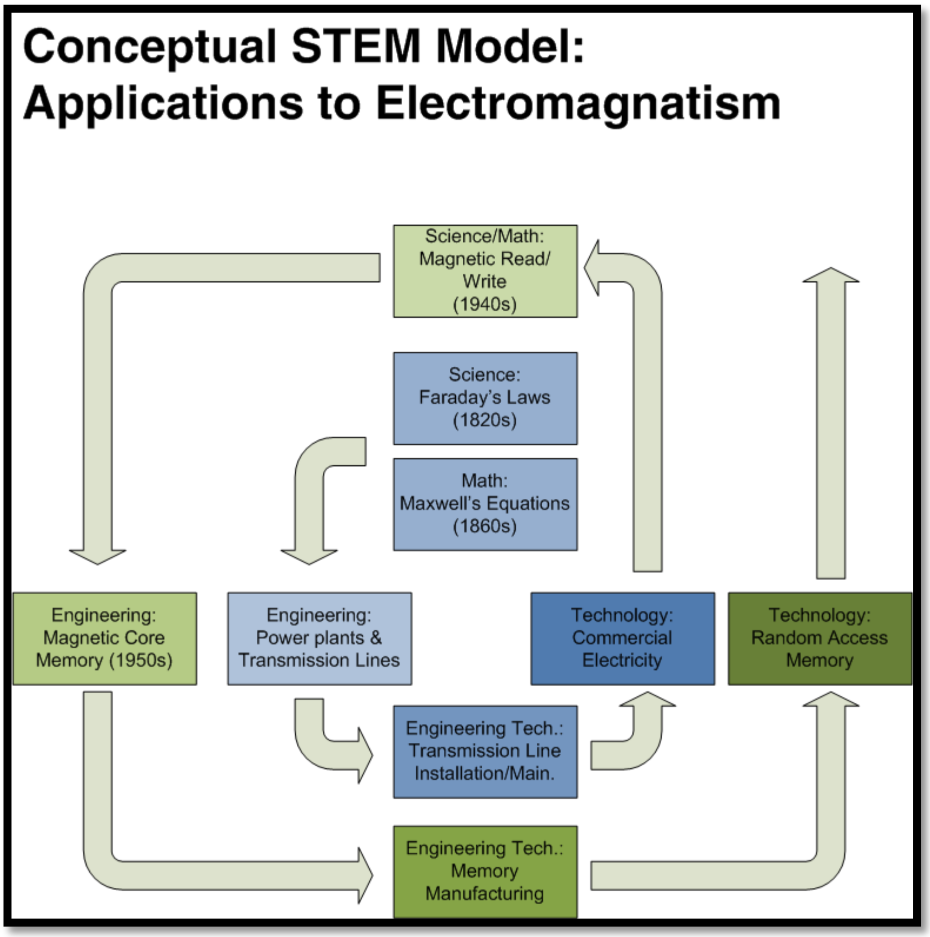
The final synthesis for developing our conceptual understanding of STEM was inspired by Minnesota Department of Education STEM Specialist, Dr. Joel Donna. In his work, Donna (2009) discussed the idea of "integrative STEM." While integrative STEM in not a new idea, we found that Dr. Donna's examination of the intricate and inexorable relationships between science, technology, engineering and math helped ground our idea of STEM as a process. Our conceptual understanding of STEM, based on these ideas is thus revealed in Figure 1.

Figure 1. Conceptual model of STEM as an integrative process.



To understand how our conceptual model weaves these ideas together, we used the concept of electromagnetism and its evolution as demonstrated in Figure 2.

Figure 2. Conceptual STEM model applications to electromagnetism.



> "Enormous economic gains can be traced to research in harnessing electricity, which grew out of basic research (such as that conducted by Michael Faraday and James Maxwell) and applied research (such as that by Thomas Edison and George Westinghouse). Furthermore, today's semiconductor integrated circuits can be traced to the development of transistors and integrated circuits, which began with basic research into the structure of the atom and the development of quantum

mechanics by Paul Dirac, Wolfgang Pauli, Werner Heisenberg, and Erwin Schrodinger and was realized through the applied research of Robert Noyce and Jack Kilby. In virtually all those examples, the original researchers did not—or could not—foresee the consequences of the work they were performing, let alone its economic implications. The fundamental research typically was driven by the desire to answer a specific question about nature or about an application of technology. The greatest influence of such work often is removed from its genesis, but the genius of the US research enterprise has been its ability to afford its best minds the opportunity to pursue fundamental questions" (National Academy of Sciences, 2007, pg 51)

5. Consideration and Methodology

Having developed our conceptual definition of STEM, we then moved towards creating a technical definition of STEM capable of yielding quantitative data. We first discussed the new STEM model and the importance of interconnectivity and the flow between science, technology, engineering and math.

Most important to our methodology was the pursuit objectivity. As opposed to evaluating CIPs at face value against our preconceived biases, including/excluding CIPs for funding purposes, or using a word within the CIP program title, we chose to use the six-digit CIP to locate the descriptive narrative within the *CIP Definition Guidebook* and assessed those CIPs based on the stated wording in contrast to our conceptual STEM model. CIPs included in our definition were chosen because they were involved in testing, designing, creating and maintaining technology and using it to advance human knowledge. Of course, some degree of subjectivity will be present in our selection as some CIPs were not always evident in how they would operate within our STEM model. However, we felt our methodology based on the objective narratives best limits the opportunity of arbitrary inclusion of certain CIPs within STEM or attempts to discredit our definitions using slippery-slope assertions.

As we stated, a certain degree of ambiguity was present for a number of CIPs due to the short narratives provided within the CIP guidebook and our lack of exposure to those programs. For CIPs that were questionably STEM, we utilized our database of consensus among technical STEM definitions by other entities. This was valuable as it gave us a barometer for understanding what other institutions regard as STEM and how many of them regard certain CIPs as STEM. While we are not required to follow a specific standard, nor duplicate the understanding of STEM by another institution, this gave us an idea of where our conclusions fell within the definition continuum. Further, we were able to articulate the reasons for our deviation from other institutions in our definition and justify specific CIPs for inclusion. While this was not a significant determinate in how we selected CIPs for STEM, it was useful in indicating which CIPs deserved greater attention and focus as we considered the meaning of the each CIPs stated definition within the guidebook.

In our discussions we had contention regarding agriculture, nursing, and logistics. With Agriculture and Nursing, the ability of these subjects to fit into the STEM model was questioned. Ultimately we chose to include certain Agriculture programs like Biotechnology as it is the foundation for bridging inorganic technology and organic manipulation. On the other hand, we chose to exclude Nursing (51.1601) on the grounds that while nurses are a critical aspect of healthcare infrastructure, they primarily use technology to identify already understood health issues and tend to be less involved in design, creation and maintenance of technology. We anticipate controversy to arise from this decision as there appears to be a divide over Nursing amongst our institutions. Four of the ten institutions in our study included Nursing: Iowa Board of Regents, STEM Equity Pipeline, Iowa Workforce Development and the Minnesota Department of Education. Those that chose not to include nursing were: the National Science Foundation, the National Center for Educational Statistics, the University of Wisconsin System, the Missouri Department of Higher Education and Minnesota State Colleges and Universities. Given the divide on Nursing and our confidence in our methodology, we felt the exclusion of Nursing was justified.

With Logistics, we questioned the use of science and mathematics with the precise definition of engineering. In particular, we discussed whether processes that utilized math were essentially technology or merely management tool. Further, we needed to determine whether technology needed to be tangible. Ultimately, we concluded that while technology in STEM need not necessarily be tangible, it most often is and that we are generally averse to including management principles in STEM unless they clearly fall within the STEM model. Further, while 5 of our 10 institutions included Business Management, Marketing, and Related Support Sciences (CIP Group 52.00) within their definitions of STEM, of the 94 six-digit CIPs within this group only 12 CIPs were considered by any institution and only two codes being considered STEM by more than one institution, 52.1304 Actuarial Science was regarded as STEM by four institutions and 52.1201, Management Information Systems was considered STEM by two institutions.

So while roughly half our institutions considered at least one CIP from Business Management in their definition of STEM, no institution regarded the entire group as STEM and a super-minority of those CIPs were considered STEM by those institutions. Further, no institution regarded Logistics (52.0203) as STEM. Given these considerations, logistics was not included.

In reviewing the implications of our conclusions on STEM we compared our selections with another entity in Iowa, the Board of Regents. In this we found a considerable amount of agreement between our definitions and the Board of Regents.

The vast majority of CIPs offered by Iowa's community colleges are not recognized as STEM by either the Board of Regents or the Committee. Of the 231 CIPs offered by Iowa's community colleges 162 were not recognized by either the Committee or the Regents. Of the 69 remaining CIPs, 48 are considered STEM by the Committee but are not offered by Iowa's State Universities. Since they do not offer these programs, we can conclude that variation between the purposes of an institution will yield reasonable differences in STEM definition.

Of the 21 remaining CIPs, 9 are considered to be STEM by the Committee and the Board of Regents. Taken together, there is agreement on 219 or 94.8 percent of all CIPs offered by Iowa's Community Colleges.

The following were considered STEM by Board of Regents but were excluded from our definitions: Agriculture, Environmental Studies, Natural Resources Management, Nursing, E Agribusiness, Arboriculture, Mortuary Science, Dental Hygiene, Radiologic Technology, Human Services/Disability Studies, Logistics, and Construction Management. Each of these CIPs were questioned and excluded for different reasons.

Some were excluded by the fact that they were more focused on business management than on science or engineering. Others were excluded because the use of the word "science" within the CIP title but their use was not reflective of our understanding of the scientific process. Others still were excluded because while they superficially would be considered STEM, we could not rationally justify their inclusion using our understanding of STEM as a process.

6. Results

Based results produced by our methodology, using a conceptual STEM model, we found that the commonly referred to gender gap in STEM enrollment is applicable and significant for Iowa's community colleges. The Iowa Department of Education maintains the Community College MIS, which contains enrollment and outcomes information for all community college students in Iowa.

According to 2007-08 enrollment data, roughly 84.05% of all STEM majors were male while only 15.82% were female. This is nearly a 6:1 ratio of male-to-female enrollment in STEM majors. That proportion is significantly different from the 1:1.45 male-to-female ratio in Iowa community colleges (Iowa Department of Education, 2009).

To understand the breakdown of ethnic demographics, one needs to understand the current ethnic make-up of Iowa community colleges. Whites comprise 89% of enrollment in Iowa community colleges, while 3.6% are black, 2.2% are Hispanic, and persons of Asian descent comprise 1.8 percent (Iowa Department of Education, 2009). In relation to STEM enrollments, we found that whites make up roughly 83.83%, black persons 3.66% and Latino or Hispanics 2.84%. This suggests that black and Hispanic/Latino students are proportionately reflected in STEM programs.

For the state of Iowa, we can infer that the gender gap between male and female enrollment at post-secondary, community college institutions remains significant. However, there are positive indicators for racial equity in proportional enrollment amongst white, black and Latino or Hispanic persons in STEM programs. Further analysis suggests that certain programs have gender concentrations that favor women over men. Given the overwhelming proportion of males to STEM, it is understandable that the majority of programs are dominated by men. Interestingly, females outnumber males in Animal Production Technology and Dental Laboratory Technology nearly 4:1. Females also represent a majority of Biotechnology students. Understanding the attraction of females to these specific programs may assist in formulating initiatives to address gender equity issues in other STEM programs.

In respect to ethnicity, the proportion of whites over other ethnicities in the general population makes extrapolating meaningful inferences difficult within our dataset. In reviewing the data, we found that the programs with higher general enrollment have higher proportion of minority students. Programs with low enrollment frequently have a handful of minority students and many have none. To what degree this is simply a reflection of Iowa's general demographics and overrepresentation of males in STEM programs or a function of racial inequity is difficult to ascertain within this study.

Table 2

Totals between Iowa Community College STEM programs by Student Gender and Ethnicity by Program Enrollment

CIP	Description	Gender: Male	Gender: Female	Gender: Unknown	Race/Ethnicity: American Indian	Race/Ethnicity: Asian	Race/Ethnicity: Black	Race/Ethnicity: Hispanic/ Latino	Race/Ethnicity: White	Race/Ethnicity: Not Provided	Race/Ethnicity: Unknown	Program Total
11010302	INFORMATION TECHNOLOGY	71.3%	28.7%	-	-	4.4%	7.6%	3.2%	73.7%	11.2%	-	251
11090102	COMPUTER SYSTEMS NETWORKING & TELECOM. TECHNO.	88.9%	11.1%	-	1.1%	1.1%	1.1%	1.9%	92.7%	2.2%	-	371
11100302	COMPUTER AND INFORMATION SYSTEMS SECURITY TECHN	68.5%	31.5%	-	-	-	-	1.9%	96.3%	1.9%	-	54
14030102	BIOPROCESSING ENGINEERING ETHANOL TECHNOLOGY	94.1%	5.9%	-	-	-	-	5.9%	94.1%	-	-	17
15000002	ENGINEERING TECHNOLOGY	91.4%	8.6%	-	-	-	-	5.7%	94.3%	-	-	35
15030302	ELECTRONICS ENGINEERING TECHNOLOGY	91.1%	8.9%	-	0.4%	2.0%	4.9%	3.8%	81.4%	7.3%	0.18%	549
15061302	MANUFACTURING TECHNOLOGY	93.3%	6.7%	-	2.2%	-	-	-	91.1%	6.7%	-	45
15130602	MECHANICAL DRAFTING/CAD/CADD TECHNOLOGY	87.7%	10.7%	1.6%	1.0%	1.3%	1.3%	3.1%	83.0%	10.2%	-	383
26120102	BIOTECHNOLOGY	41.0%	59.0%	-	-	1.6%	8.2%	-	80.3%	9.8%	-	61
11020202	COMPUTER PROGRAM. SPECI. APPLICA. TECHNOLOGY	76.0%	24.0%	-	1.0%	2.6%	6.2%	3.1%	77.1%	10.0%	-	807
11100402	WEB/MULTIMEDIA MANAGEMENT AND WEBMASTER TECHNOLOGY	50.0%	50.0%	-	-	-	-	-	100.0%	-	-	8
11109902	COMPUTER AND INFORMATION SYSTEMS TECHNOLOGY	80.2%	19.8%	-	1.0%	1.7%	4.8%	2.7%	77.8%	11.9%	-	293
14380112	GLOBAL IMAGING SYSTEMS TECHNOLOGY	85.4%	14.6%	-	-	-	-	-	97.6%	2.4%	-	41
15010102	ARCHITECTURAL ENGINEERING TECHNOLOGY	83.3%	16.7%	-	6.7%	-	-	16.7%	60.0%	16.7%	-	30
15020102	CIVIL ENGINEERING TECHNOLOGY	85.6%	14.4%	-	-	-	3.8%	0.8%	86.4%	9.1%	-	132
15030402	LASER AND OPTICAL TECHNOLOGY	93.1%	6.9%	-	-	-	3.4%	-	93.1%	3.4%	-	29
15030502	TELECOMMUNICATIONS TECHNOLOGY	87.8%	12.2%	-	9.8%	-	-	-	73.2%	17.1%	-	41
15040102	BIOMEDICAL TECHNOLOGY	100.0%	-	-	-	-	-	50.0%	50.0%	-	-	2
15040502	ROBOTICS TECHNOLOGY	91.9%	8.1%	-	-	-	-	5.4%	94.6%	-	-	37
15050312	SUSTAINABLE ENERGY SYSTEMS TECHNOLOGY	100.0%	-	-	-	-	-	-	100.0%	-	-	12
15050602	WATER QUALITY, WASTEWATER TREATMENT TECHNOLOGY	82.1%	17.9%	-	-	-	7.7%	2.6%	74.4%	15.4%	-	39
15050702	ENVIRONMENTAL ENGINEERING TECHNOLOGY	70.3%	29.7%	-	1.6%	1.6%	4.7%	1.6%	84.4%	6.3%	-	64
15110300	HYDRAULICS AND FLUID POWER	-	-	-	-	-	-	-	-	-	-	0
15130110	DRAFTING AND DESIGN ASSISTANT	75.0%	25.0%	-	-	12.5%	-	-	87.5%	-	-	8
15130302	ARCHITECTURAL DRAFTING/CAD/CADD TECHNOLOGY	82.0%	18.0%	-	0.6%	1.7%	1.2%	2.3%	88.7%	5.5%	-	344
15130401	CIVIL DRAFTING/CAD/CADD TECHNICIAN	82.4%	17.6%	-	-	5.9%	-	-	94.1%	-	-	17
41010102	BIOLOGICAL LABORATORY TECHNOLOGY	76.9%	19.2%	3.8%	-	-	-	-	100.0%	-	-	26
41030102	CHEMICAL TECHNOLOGY	73.3%	26.7%	-	3.3%	-	-	3.3%	93.3%	-	-	30
46030201	ELECTRICAL TECHNICIAN	94.0%	6.0%	-	2.4%	-	1.2%	4.8%	81.0%	10.7%	-	84
46030301	LINE WORKER TECHNICIAN	100.0%	-	-	-	-	1.0%	-	88.3%	10.7%	-	103
47010502	INDUSTRIAL ELECTRONICS TECHNOLOGY	96.0%	4.0%	-	0.3%	1.0%	3.7%	4.7%	84.6%	5.7%	-	298
47020101	HEATING/AC/VENTILATION/REFRIG. MAINTEN. TECHNI.	100.0%	-	-	2.8%	1.9%	5.6%	7.4%	73.1%	9.3%	-	108
47030301	INDUSTRIAL EQUIPMENT MAINTENANCE TECHNICIAN	96.6%	3.4%	-	-	2.3%	4.5%	2.3%	85.2%	5.7%	-	88
47040402	MUSICAL INSTRUMENT FABRICATION & REPAIR TECHNOLOGY	71.4%	28.6%	-	-	-	-	-	71.4%	28.6%	-	21
48050101	MACHINE TOOL TECHNICIAN	100.0%	-	-	-	-	-	-	100.0%	-	-	12
48050602	PRECISION SHEET METAL TECHNOLOGY	75.0%	25.0%	-	-	-	-	-	100.0%	-	-	4
48050702	TOOL AND DIE TECHNOLOGY	97.1%	2.9%	-	1.5%	1.5%	3.7%	2.9%	79.4%	11.0%	-	136
11100102	SYSTEMS ADMINISTRATION TECHNOLOGY	90.2%	9.8%	-	0.6%	1.2%	3.5%	-	89.0%	5.8%	-	173
01000002	AGRICULTURAL SCIENCE TECHNOLOGY	85.7%	14.3%	-	-	2.0%	-	-	95.9%	2.0%	-	49
52200102	CONSTRUCTION MANAGEMENT	100.0%	-	-	-	-	-	-	100.0%	-	-	1
01020412	AGRICULTURAL POWER TECHNOLOGY (J.D.)	97.0%	3.0%	-	-	-	-	-	92.4%	7.6%	-	66
01030202	ANIMAL PRODUCTION TECHNOLOGY	22.6%	77.4%	-	-	-	3.2%	3.2%	90.3%	3.2%	-	62
46050312	GAS UTILITY TECHNOLOGY	100.0%	-	-	-	-	-	4.5%	86.4%	9.1%	-	22
47010302	COMMUNICATIONS SYSTEMS TECHNOLOGY	93.8%	6.3%	-	-	-	6.3%	-	90.6%	3.1%	-	32
48070301	CABINETMAKING AND MILLWORKING TECHNICIAN	90.5%	9.5%	-	-	4.8%	9.5%	9.5%	42.9%	33.3%	-	21
51060302	DENTAL LABORATORY TECHNOLOGY	18.5%	81.5%	-	-	-	14.8%	3.7%	51.9%	29.6%	-	27
Total		**4,230**	**796**	**7**	**41**	**80**	**184**	**143**	**4,179**	**405**	**1**	**5033**
Percent		**84.05%**	**15.82%**	**0.14%**	**0.81%**	**1.59%**	**3.66%**	**2.84%**	**83.03%**	**8.05%**	**0.02%**	**100%**

However, there are a number of concerns to be acknowledged in moving towards national standards. First, such a move would be controversial as STEM may be a source of major funding for many valuable programs that could be excluded from revised definitions. Further, one of the major underpinnings of STEM initiatives is innovation and creativity. Would national standards suppress or dissuade innovative programming from occurring? Is this an acceptable risk in pursuit of cross-applicability and program accountability? Another issue to be addressed is the STEM pipeline and to what degree the different stakeholders (K-12, community colleges, universities, workforce development agencies, not-for-profit local, state, regional and national partners, federal agencies, education professionals, administrators, and funding bodies) have inherently different missions and contributions regarding STEM that would warrant differing definitions of STEM and how or if these issues can be reasonably reconciled. Such concerns would need to be addressed and brought before stakeholders in order to find the most productive method for developing a more meaningful and effective STEM definition.

There are opportunities to address these issues in the future. First, any number of entities can assume the role of speaker to generate a grass-roots dialog regarding STEM programming and STEM conceptual and technical definitions. Second, the process of updating the CIP 2000 guidebook is underway and will soon be updated for 2010. Entities that track and report data on STEM will may need to revise their collection and reporting system to reflect those changes. Since this will need to be done by the majority of STEM stakeholders, this event could act as a catalyst for institutions to adopt or make changes to their own definitions of STEM.

Clearly defining STEM—both conceptually and programmatically through CIPs—can enhance the evaluation of STEM programming. In particular, state longitudinal data systems implements through recent Institute for Education Sciences grants and mandated by the American Recovery and Reinvestment Act (State Fiscal Stabilization Fund

Program, 2009) and Race to the Top (Overview Information; Race to the Top Fund; Notice Inviting Applications for New Awards for Fiscal Year (FY) 2010, 2009) have equipped states to study long-term outcomes of STEM curriculum. For example, Iowa has spent nearly $3 million on implement Project Lead The Way, a hands-on STEM curriculum in middle and high schools. The Iowa Department of Education has launched an evaluation which will measure whether PLTW casually increases participation in STEM majors in postsecondary institutions (Schenk, Rethwisch, Laanan, Chapman, Starobin, and Zhang, 2009). The evaluation will measure the likelihood of participating in the aforementioned CIPs after participating in PLTW.

Regardless of the position of a STEM stakeholder concerning technical definitions; it is our desire to encourage discussion regarding the purpose and definition of STEM within the United States. If we can promote discussion amongst the numerous and diverse entities that are involved in STEM, we can foster a culture of cooperation amongst STEM entities. Hopefully, with a culture of cooperation amongst STEM stakeholders, we can begin to see more significant progress in addressing the various problems that persist within the STEM pipeline; ultimately resulting in more positive economic and socially equitable outcomes for students, workers, educators and businesses within the United States**.**

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