How Does Applied STEM Coursework Relate to Mathematics and Science Self-Efficacy Among High School Students? Evidence from a National Sample.

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Abstract

Over the past decade, CTE has been highlighted as a means of promoting college and career readiness for high school students. Applied STEM coursework is a promising area of high school study that has particular relevance in the technologically progressive world of today. Previous research has illustrated that applied STEM coursework in high school is associated with a number of positive educational outcomes. Importantly, no previous empirical investigation has examined the relationship between applied STEM coursework and students' reported levels of math and science self-efficacy, two important harbingers of academic ability and success. Consequently, the current study used nationally representative data to explore applied STEM coursework participation and self-efficacy. Results indicated that applied STEM coursework was predictive of increases in both math and science self-efficacy, except among females and students with disabilities (SWDs). Implications for policy are discussed.

Keywords: applied STEM, career and technical education, mathematics and science education, STEM learning, education policy, self-efficacy

Introduction

Education and employment in the science, technology, engineering, and mathematics (STEM) fields has been a key focus of federal, state, and local education policies for decades (National Science Board, 2010). Labor statistics project large growth in the STEM labor market over the next decade, while simultaneously experts express concern that the nation is not educating sufficient numbers of STEM-prepared students (ACT, 2013; Bureau of Labor Statistics, 2013). For example, the proportion of students pursuing engineering degrees actually experienced a decline of about four tenths of a percent between the years of 2000 and 2012 (Snyder, de Brey, & Dillow, 2016). However, the projected growth of jobs within the engineering sector is expected to approach 8.6% over the subsequent decade from 2012 to 2022 (Sargent Jr., 2014). While this may not be the case in every STEM field, there are evident gaps in certain STEM areas.

In an effort to improve STEM achievement and attainment in the country, numerous initiatives and efforts have been implemented (Sublett, 2016). These initiatives have focused on, among other things, college readiness, and STEM curriculum and pathways. In addition to looking directly at improvement in achievement in STEM, researchers have also explored how to improve students' perceptions of their abilities – also known as self-efficacy (Pajares & Miller, 1994; Zimmerman, Bandura, & Martinez-Pons, 1992). One of the reasons for focusing on self-efficacy is due to the positive relationship between self-efficacy and achievement, but an equally important motivation is due to the understanding that self-efficacy is a malleable trait that can be taught and fostered (Komarraju & Nadler, 2013). One area that highlights this notion of self-efficacy as it is encompassed within both college readiness and STEM curriculum is career and technical education (CTE).

Over the past decade, CTE has been highlighted as a key means of promoting college and career readiness for high school students. The reauthorization of the Carl D. Perkins Career and Technical Improvement Act of 2006 included language encouraging the alignment of CTE with more academic courses in an effort to increase the rigor and relevance of the CTE curriculum. Critical thinking, quantitative reasoning, and problem solving skills are increasingly necessary traits for students to master in order to adapt to a society promoting near constant innovation. Science, technology, engineering, and mathematics (STEM) coursework represents an important strand of high school instruction that can help students meet these demands. Within the broad spectrum of CTE coursework exists one key area of study that has particular relevance in the technologically progressive world of today: applied STEM.

Applied STEM Coursework

Within the area of STEM coursework, there are two well-defined areas: academic STEM and applied STEM. Academic STEM courses are taught predominantly through theoretical approaches that focus on procedures, observation, identification, computation, and documentation (Plasman & Gottfried, 2016). The abstract nature of these courses can act to discourage students who struggle with this type of learning. The lack of connection between concepts taught across the academic STEM spectrum may result in an inability for students to see the application of these concepts in real-life (Stone & Lewis, 2012). As engagement with the STEM material subsequently declines, students exit the STEM pipeline for alternative options (Hampden-Thompson & Bennett, 2013; Weinberger, 2004; Wilson, 2003).

Unlike traditional academic STEM courses which tend to be quite abstract and theoretical, applied STEM courses are stressed as being taught through more hands-on and educationally engaging methods (Bozick & Dalton, 2013; Gottfried, Bozick, & Srinivasan, 2014). They are designed to be more skills based, and focus on more direct challenges as they relate to real-world problems (Gottfried & Sublett, 2017). The ultimate goal for many of these applied STEM courses is to act as a supplemental learning opportunity and ultimately to help contextualize the concepts learned in traditional STEM courses. The potential for applied STEM courses to further elucidate the relationship of STEM concepts places students in an advantageous position for developing important skills as they progress through the STEM pipeline (Stone, Alfeld, & Pearson, 2008; Stone & Lewis, 2012).

Applied STEM courses fall within two broad categories of CTE: computer and information sciences (CIS), and engineering and technology (ET) (Bradby & Hudson, 2007; Bradby, Pedroso, Rogers, & Hoffman, 2007). CIS courses teach programming skills and systems functionality through the design, development, and support across systems, hardware, and software. CIS courses include introduction to computers, information management, webpage design, and computer programming. ET courses teach students problem-solving skills through the scientific research process and examination of technical services. Courses in this category include drafting careers exploration, emerging technologies, and principles of engineering. Each of these courses helps to highlight the application of math and science concepts learned in traditional STEM courses through the incorporation of practical experiences and hands-on approaches to logic, problem solving, and critical thinking skills.

Applied STEM has been theorized to connect with various end of high school, as well as post-secondary, outcomes through a framework based on the goals of applied STEM courses as they are designed. The framework proposes the existence of three key mechanisms: augmentation, relevance, and new skill development (Gottfried, 2015). Augmentation refers to the reinforcement of concepts learned in traditional STEM coursework. In applied STEM courses, students are able to utilize math and science skills in new and different ways, helping to promote a more thorough understanding of the material. Second, applied STEM coursework may help to provide a method for translating theoretical material into more accessible and directly applicable skills, thereby helping to solidify foundational material while also promoting relevance to life beyond high school. Finally, applied STEM courses promote the development of new skills such as reasoning, logic, and problem solving. Learning these skills in an applied setting can have the added benefit of providing students with a personal belief of their abilities.

Self-Efficacy

Belief in oneself is key to success. One important precursor to the growth in these STEM skills is belief by students that they have the ability to succeed. This personal belief, or self-efficacy as originally described by Bandura (1977) and later incorporated into his social cognitive theory, plays a key role in the development of an individual as a person, as well as an individual as a learner in an academic setting. Through this concept of self-efficacy, an individual's belief in his/her ability plays a major role in ultimately determining behavior. Social cognitive theory presents the idea that an individual's behavior can be shaped by his or her thought processes and overall reflection (Bandura, 1986). As an individual reflects on personal behavior and attainment, the interpretation of these behaviors may reinforce or weaken self-belief, which therein impacts behavior (Pajares, 1996). This cycle of belief in one's abilities, performance/behavior, reflection, and alteration of beliefs impacts students such that they tend to shy away from participation in activities/behaviors in which they feel inadequate, and engage in activities/behaviors in which they feel competent (Pajares, 1996). Self-efficacy ultimately plays a role in determining choice of activities and environments, effort expenditure, persistence, thought patterns, and emotional reactions when faced with a challenge (Lent, Brown, & Hackett, 1994).

In specific areas, such as mathematics or science, high levels of self-efficacy can encourage increased interest in the subject, which in turn leads to increased achievement, and a continued path down the math or science pipeline (Wang, 2013). Math self-efficacy specifically refers to students' perceptions of confidence in their abilities to perform well on math related tasks (Ayotola & Adedeji, 2009). Previous research has established a strong connection between high levels of mathematics self-efficacy and persistence through the overall STEM pipeline, as well as performance on STEM tasks and math achievement (Ayotola & Adedeji, 2009; Betz & Hackett, 1983; Hackett & Betz, 1989). Harlow et al. (2002) showed empirically that math self-efficacy is a malleable trait that can enhanced through the use of appropriate learning techniques in traditional STEM courses.

The Connection between Applied STEM and Self-Efficacy

Considering the importance of belief in self, the promotion of self-efficacy in relation to STEM learning is therefore vital for ensuring students achieve at the highest levels, and continue to pursue STEM education in postsecondary institutions and STEM fields as careers. Using Bandura's (1986) social cognitive theory – through which he explains that an indivual's belief in his/her abilities to perform certain tasks is directly related to the ultimate accomplishment of those tasks – as a guiding framework, applied STEM coursework offers a potential opportunity to encourage growth in self-efficacy in the areas of math and science. Work by Tobias (1993) and Springer el al., (1999) has highlighted the necessity for offering applied work through more relevant learning opportunities in promoting self-efficacy and decreasing math anxiety. As mentioned above, applied STEM courses promote student learning in STEM fields through experiential learning opportunities in combination with the theoretical learning from traditional academic STEM courses in such a way that helps contextualize the information learned in these traditional classes (Gottfried & Sublett, 2017). Through these learning techniques, students may gain confidence in their STEM skills and increase interest in STEM learning overall (National Research Council, 2011). The gained confidence is then reflected in increased self-efficacy, and this increase in interest has been theorized to connect to persistence in the overall STEM pipeline, which itself is enhanced through growth in self-efficacy in math and science (Plank, DeLuca, & Estacion, 2008).

Previous research has connected coursetaking in applied STEM to increased odds of graduation, increased odds of advancing further in traditional mathematics and sciences courses in high school, and increased odds of pursuing STEM studies in postsecondary education (Gottfried, 2015; Gottfried & Bozick, 2016; Gottfried et al., 2014; Plasman & Gottfried, 2016; Sublett, 2016). Each of these studies explored the connection between applied STEM and these numerous STEM outcomes through a conceptual framework that identified increased self-efficacy as a key aspect for improving results. In conjunction with two other key mechanisms – relevance and engagement – self-efficacy has been theorized as a driving force in nearly all aspects of growth. While previous research has shown that enhanced learning techniques taught in traditional STEM courses can help to increase self-efficacy (Harlow, Burkholder, & Morrow, 2002), growth in math and science self-efficacy through participation in applied STEM has never been empirically tested.

Applied STEM across student populations

There is reason to believe that male and female students exhibit different levels of math self-efficacy, with most research pointing to the idea that male students tend to have higher math self-efficacy than their female counterparts (Lent, Lopez, & Bieschke, 1991; Pajares & Miller, 1994). Furthermore, research has shown that students with disabilities tend to miss out on opportunities to develop self-efficacy (Hampton & Mason, 2003). Therefore, an examination of how applied STEM may differentially relate to self-efficacy patterns across gender and disability stands to provide valuable insight into opportunities to help reduce gaps in STEM across groups.

In addition to the benefits of applied STEM coursework for the population in general, previous research has examined the robustness of results across subpopulations of students with disabilities, and for female students. These studies looked to determine whether applied STEM coursework provided an additional boost for either of these specific populations. With respect to students with learning disabilities, the conceptual framework outlining three specific mechanisms becomes more accentuated, as a key accommodation for students with learning disabilities is to employ teaching techniques that focus on more experiential and hands-on learning. Specifically, the research found that applied STEM was associated with additional assistance in graduating from high school above and beyond the boost for the general population (Plasman & Gottfried, 2016). That is to say, students with learning disabilities benefited more from these applied STEM courses when it came to high school completion. Additional research on the relationship between students with learning disabilities looked to explore the relationship between applied STEM coursetaking, and math achievement and advanced math/science coursetaking (Gottfried & Sublett, 2017). Results showed that while there was a significant positive association for the general population, this relationship did not hold true for students with learning disabilities.

Previous research supports that outcomes related to applied STEM may differ across gender as well. Sublett and Gottfried (2017) found that female students were less likely to enroll in high school applied STEM courses than were their male counterparts. This finding, combined with research indicating that female students are less likely to major in STEM in college indicates that the STEM gender gap is evident in high school, and applied STEM coursework does not appear to be helping to close this gap (Gottfried & Bozick, 2016). Recent research has also suggested that female students may benefit more than male students from participation in engineering CTE coursework as it relates to eventual receipt of an engineering degree (Gottfried & Plasman, *in press*). The differential relationships observed regarding the above-mentioned outcomes across subgroups suggest that it may also be beneficial to examine math and science self-efficacy outcomes of various subgroups separately (e.g., male compared to females, or students with disabilities compared to students without disabilities).

Considering the need to increase the STEM workforce in the United States, the growth of rigor and relevance of applied STEM and CTE in general in high schools, and the pending reauthorization of the Perkins Act, it becomes more and more important to understand the role that these applied STEM courses are playing in the lives of students. Self-efficacy, as it is connected to STEM fields, is a vital area of research as it relates to persistence in STEM. While there has been research into mathematics self-efficacy specifically, none of the existing research has examined the role that applied STEM coursetaking plays in self-efficacy growth. Furthermore, the theorized notion that the positive outcomes related to applied STEM are promoted through development of self-efficacy is a key assumption in much of the previous research on applied STEM. However, this connection has never been empirically tested. With this gap in the literature in mind, we ask the following research questions:

RQ1: Is completion of applied STEM coursework in high school associated with a growth in mathematics self-efficacy during high school?

RQ2: Is completion of applied STEM coursework in high school associated with a growth in science self-efficacy during high school?

RQ3: Do these relationships hold for both males and females?

RQ4: Do these relationships hold for students with disabilities?

Data and Method

Data for the current study came from the High School Longitudinal Study of 2009 (HSLS:09), a nationally-representative, multi-year data collection effort by the National Center for Education Statistics (NCES). Data for HSLS were collected over several waves spanning from the fall of 2009, when participants were in the 9th grade, to 2013 when most participants had graduated high school (Ingels et al., 2015). HSLS:09 contains a rich panel of data that touches on many aspects of high school students' academic, personal, familial, behavioral and attitudinal characteristics. These data are complemented with information gathered from parent, teacher and administrator questionnaires. In addition, complete high school transcripts for participants were made available in restricted versions of the data set. These transcript data provide detailed coursetaking information for student participants that allowed the authors of the current study to know the types of courses students completed in high school.

There were a number of missing observations on the key variables of interest for the current study and in order to maintain sufficient statistical power while also controlling for the potential influence of missing observations we chose to use multiple imputation (McCleary, 2002; Royston, 2004). In more detail, ten sets of plausible values were estimated and then imputed back to the sample in cases in which NCES-provided sample weights were set to nonzero. These weights were used for imputation and during all empirical analyses. Throughout the current study sample sizes have been rounded to the nearest tens digit per NCES guidelines. After multiple imputation, the final analytic sample was composed of approximately 20,000 students from nearly 850 schools.

Measures

The primary outcome variable of interest for the current study was participants' self-reported levels of (1) math and (2) science self-efficacy. Student participants reported their self-efficacy in math and science at two time points during HSLS:09. The first was during the initial wave of data collection, when students were in the 9th grade. The second was when the majority of students were in the 11th grade. Both math and science self-efficacy measures were created by NCES using principal components factor analysis and were standardized with a mean of 0 and a standard deviation of 1. Inputs for the math self-efficacy measure included students' reported abilities to: take math tests, understand math textbooks, master math skills, and perform well on math assignments. Inputs for the science self-efficacy measure included students' reported abilities to: take science tests, understand science textbooks, master science skills, and perform well on science assignments. Students who did not provide complete responses to each input item were not assigned a self-efficacy scale value and, consequently, were treated as missing and not included in the analyses reported below. The reliability coefficient for both self-efficacy measures (math and science) was reported by NCES as $\alpha = 0.65$ (Ingels et al., 2015). In all of the subsequent empirical analyses we report, we used the 11th grade measure of math and science self-efficacy as the outcome variable while including students' 9th grade self-efficacy measures (math or science, depending on which outcome we were modeling) as a statistical control. Consequently, the results of our empirical models can be interpreted as average increases or decreases in self-efficacy among students in the analytic sample.

The main predictor, or "treatment," variable for the current study was applied STEM coursework in high school. We used high school transcripts to identify the applied STEM coursetaking behaviors of students in the sample. To do this, we used the Secondary School Taxonomy (Bradby & Hudson, 2007) which organizes students high school coursework into the following categories: career and technical education (CTE), academic, enrichment and special education. Applied STEM coursework falls exclusively within the CTE category of high school coursework using this taxonomy. As we detailed earlier, there are two types of applied STEM courses: "computer and information sciences" (CIS) or "engineering and technology" (E&T) courses.

We found it most informative to operationalize the main predictor variable – applied STEM coursework – in three ways. The first measure of applied STEM coursework in high school was the (1) total number of applied STEM credits a student earned throughout high school, from 9th through 11th grades. To identify whether the association between applied STEM coursework and the self-efficacy measures varied by the two varieties of applied STEM courses – CIS and E&T – , we then disaggregated this summed measure of applied STEM work into (2) the total number of CIS credits and the (3) total number of E&T credits a student earned in high school (Bradby & Hudson, 2007b).

We included a wide variety of control variables in each of our empirical models in order to reduce the impact of estimation bias. These controls included gender, ethnicity and a standardized composite measure of socioeconomic status constructed by NCES. Again, we made sure to always account for students' base-year (9th grade) self-efficacy measures. We also were sure to control for a range of other important academic characteristics. These academic characteristics included students' base-year math IRT scores, the total number of academic STEM courses students completed through the 11th grade, the number of hours a student reported spending on math homework during the week, students' postsecondary education plans, whether a student had an IEP in the 9th grade, students' 9th grade math GPA, an NCES-derived standardized measure of school engagement, and an indicator of whether a student was an "occupational concentrator" (i.e., a student had earned 3 credits in a particular occupational concentration). We also included a number of school-level variables in our empirical models. These variables included indicators for whether a school was located in a city, suburb, town or rural environment. We also controlled for the control of the school (public, catholic or "other private"), an indicator of whether 50 percent or more of the students in a school received free or reduced lunch, an indicator of whether 10 percent or more of the students in the 9th grade were repeaters, an indicator of whether a school reported having a program to encourage "underrepresented minorities" to enroll in STEM classes, and whether a school had a program to inform parents about STEM careers. Last, we included a measure that captured the degree to which schools used placement tests for 9th grade math placement.

These control variables, along with the outcome variables we previously described, are listed in Table 1 along with their respective descriptive statistics. To provide clarity around the degree to which students who did and did not earn credits in applied STEM during high school were similar or different, Table 1 divides the analytic sample into applied STEM and non-applied STEM credit-earners, with applied STEM credit-earners being the students in the sample who was listed as having non-zero credits in applied STEM during high school. As the figures in Table 1 indicate, there were just a few slight differences between the two groups of students. For example, fewer female students completed applied STEM credits in high school. This aligns with previous research findings (Sublett & Gottfried, 2017). Table 1 also indicates that applied STEM students tended to earn just under 1 additional credit in academic STEM coursework in high school relative to non-applied STEM students. For the most part, however, students who did not earn applied STEM credits in high school (*n* = 13,270) appeared to be quite similar to those who did (*n* = 11,940). For additional insight the students in the analytic sample who earned applied STEM credits in high school, Table 2 breaks down the descriptive characteristics of the sample by the number of applied STEM credits students earned in high school. Table 2 helps to unpack some of the observed patterns in Table 1. Again, females appear to earn fewer applied STEM credits in high school relative to male students. Also, as Table 1 illustrated, students who earned credits in applied STEM also earned more credits in academic stem coursework. Of great interest to the current study is the fact that it appers that students who completed more credits in applied STEM also displayed greater math and science self-efficacy. The statistical models to follow will examine the degree to which these observed differences are meaningful.

Analytic Technique

We used ordinary least squares (OLS) regression to model our stated research questions. In more detail, we began our analysis of the association between applied STEM coursework in high school and math and science self-efficacy with the following linear model:

$$Eq\ 1: Y_{is} = \alpha + \beta AS_i + \theta Z_{is} + \varepsilon_{is}$$

where Y was a self-reported measure of either math or science self-efficacy in the 11th grade for student i in school s. On the right hand side of the expression, *AS* represented one of the three main predictor variables of interest. The corresponding regression coefficient for the term AS, β, was the central focus of the current study. The term *Z* represented the complete suite of control variables listed in Table 1, including students' base-year (math or science) self-efficacy measures. The error term for this and all other models performed in this analysis, ε, was clustered at the school level to account for non-independence among students within the same schools.

To improve the precision of our estimates, we followed this baseline regression model with a school fixed effects model. Fixed effects terms within regression models help to reduce the potential threat of omitted variable bias by controlling for all observed and unobserved sources of heterogeneity. Common sources of unobserved heterogeneity in educational research with the potential to bias regression estimates include school nesting. For example, schools vary in the types of resources they allocate towards educational programs. One school may allocate vast resources to STEM programs, including many more full-time teachers, robust tutoring services, grant-funded curricula or community partnerships for students. A different school, by contrast, may not. And while researchers attempt to account for this variation by including observed and measured school-related variables in their empirical models, such statistical controls do not and cannot control for sources of important variation whenever those sources of variation are not observed or measured. HSLS:09 is a rich and informative body of data, but even after accounting for a number of important school-level variables, we chose to include a school fixed effects term which we argue improves estimation by using each school as its own control.

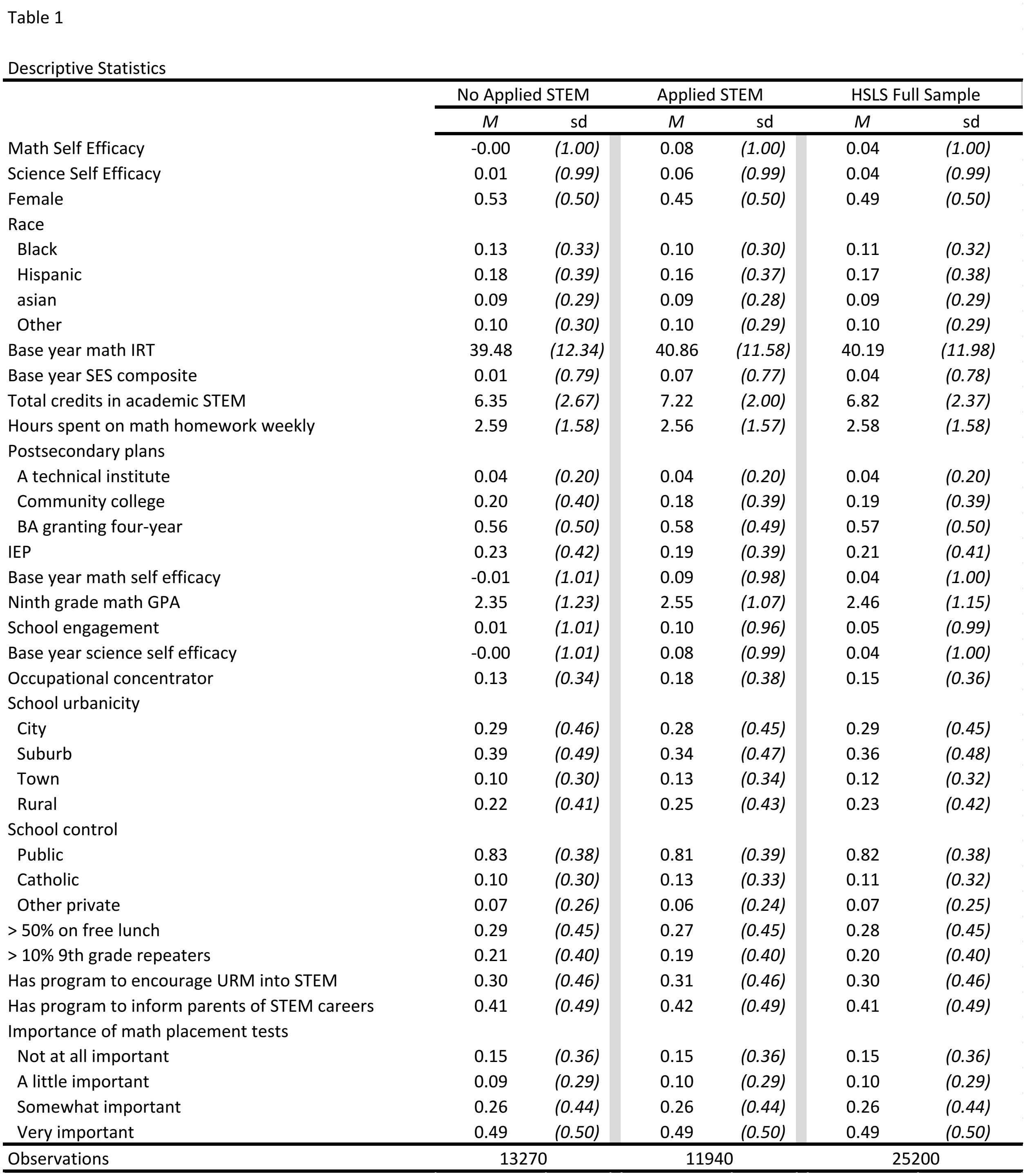


Table 1

Descriptive Statistics

	No Applied STEM		Applied STEM		HSLS Full Sample	
	M	sd	*M*	sd	*M*	sd
Math Self Efficacy	-0.00	*(1.00)*	0.08	*(1.00)*	0.04	*(1.00)*
Science Self Efficacy	0.01	*(0.99)*	0.06	*(0.99)*	0.04	*(0.99)*
Female	0.53	*(0.50)*	0.45	*(0.50)*	0.49	*(0.50)*
Race						
Black	0.13	*(0.33)*	0.10	*(0.30)*	0.11	*(0.32)*
Hispanic	0.18	*(0.39)*	0.16	*(0.37)*	0.17	*(0.38)*
asian	0.09	*(0.29)*	0.09	*(0.28)*	0.09	*(0.29)*
Other	0.10	*(0.30)*	0.10	*(0.29)*	0.10	*(0.29)*
Base year math IRT	39.48	*(12.34)*	40.86	*(11.58)*	40.19	*(11.98)*
Base year SES composite	0.01	*(0.79)*	0.07	*(0.77)*	0.04	*(0.78)*
Total credits in academic STEM	6.35	*(2.67)*	7.22	*(2.00)*	6.82	*(2.37)*
Hours spent on math homework weekly	2.59	*(1.58)*	2.56	*(1.57)*	2.58	*(1.58)*
Postsecondary plans						
A technical institute	0.04	*(0.20)*	0.04	*(0.20)*	0.04	*(0.20)*
Community college	0.20	*(0.40)*	0.18	*(0.39)*	0.19	*(0.39)*
BA granting four-year	0.56	*(0.50)*	0.58	*(0.49)*	0.57	*(0.50)*
IEP	0.23	*(0.42)*	0.19	*(0.39)*	0.21	*(0.41)*
Base year math self efficacy	-0.01	*(1.01)*	0.09	*(0.98)*	0.04	*(1.00)*
Ninth grade math GPA	2.35	*(1.23)*	2.55	*(1.07)*	2.46	*(1.15)*
School engagement	0.01	*(1.01)*	0.10	*(0.96)*	0.05	*(0.99)*
Base year science self efficacy	-0.00	*(1.01)*	0.08	*(0.99)*	0.04	*(1.00)*
Occupational concentrator	0.13	*(0.34)*	0.18	*(0.38)*	0.15	*(0.36)*
School urbanicity						
City	0.29	*(0.46)*	0.28	*(0.45)*	0.29	*(0.45)*
Suburb	0.39	*(0.49)*	0.34	*(0.47)*	0.36	*(0.48)*
Town	0.10	*(0.30)*	0.13	*(0.34)*	0.12	*(0.32)*
Rural	0.22	*(0.41)*	0.25	*(0.43)*	0.23	*(0.42)*
School control						
Public	0.83	*(0.38)*	0.81	*(0.39)*	0.82	*(0.38)*
Catholic	0.10	*(0.30)*	0.13	*(0.33)*	0.11	*(0.32)*
Other private	0.07	*(0.26)*	0.06	*(0.24)*	0.07	*(0.25)*
> 50% on free lunch	0.29	*(0.45)*	0.27	*(0.45)*	0.28	*(0.45)*
> 10% 9th grade repeaters	0.21	*(0.40)*	0.19	*(0.40)*	0.20	*(0.40)*
Has program to encourage URM into STEM	0.30	*(0.46)*	0.31	*(0.46)*	0.30	*(0.46)*
Has program to inform parents of STEM careers	0.41	*(0.49)*	0.42	*(0.49)*	0.41	*(0.49)*
Importance of math placement tests						
Not at all important	0.15	*(0.36)*	0.15	*(0.36)*	0.15	*(0.36)*
A little important	0.09	*(0.29)*	0.10	*(0.29)*	0.10	*(0.29)*
Somewhat important	0.26	*(0.44)*	0.26	*(0.44)*	0.26	*(0.44)*
Very important	0.49	*(0.50)*	0.49	*(0.50)*	0.49	*(0.50)*
Observations	13270		11940		25200	

Table 2

Descriptive Statistics by Applied STEM (AS) Coursetaking

	< 2 AS Credits		2 & 4 AS Credits		4 & 6 AS Credits		> 6 AS Credits	
	M	*sd*	*M*	*sd*	*M*	*sd*	*M*	*sd*
Math Self Efficacy	0.06	(1.00)	0.26	(0.96)	0.27	(1.04)	0.37	(0.92)
Science Self Efficacy	0.04	(1.00)	0.22	(0.92)	0.38	(0.98)	0.35	(0.77)
Female	0.47	(0.50)	0.20	(0.40)	0.21	(0.41)	0.13	(0.34)
Race	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Black	0.11	(0.31)	0.07	(0.26)	0.06	(0.24)	0.05	(0.21)
Hispanic	0.16	(0.37)	0.12	(0.33)	0.10	(0.30)	0.09	(0.29)
asian	0.09	(0.28)	0.09	(0.29)	0.12	(0.33)	0.09	(0.29)
Other	0.09	(0.29)	0.10	(0.30)	0.10	(0.30)	0.09	(0.29)
Base year math IRT	40.65	(11.55)	42.93	(11.73)	43.51	(10.83)	43.11	(12.00)
Base year SES composite	0.07	(0.77)	0.10	(0.77)	0.06	(0.69)	-0.04	(0.61)
Total credits in academic STEM	7.16	(2.02)	7.71	(1.66)	7.75	(1.39)	7.70	(1.33)
Hours spent on math homework weekly	2.56	(1.58)	2.52	(1.53)	2.62	(1.69)	2.19	(1.11)
Postsecondary plans	2.66	(0.57)	2.65	(0.60)	2.60	(0.58)	2.50	(0.69)
A technical institute	0.04	(0.20)	0.06	(0.23)	0.04	(0.20)	0.07	(0.26)
Community college	0.18	(0.39)	0.17	(0.38)	0.26	(0.44)	0.21	(0.41)
BA granting four-year	0.58	(0.49)	0.58	(0.49)	0.54	(0.50)	0.41	(0.50)
IEP	0.19	(0.39)	0.22	(0.41)	0.29	(0.46)	0.26	(0.45)
Base year math self efficacy	0.08	(0.98)	0.21	(0.96)	0.28	(0.91)	0.36	(0.82)
Ninth grade math GPA	2.54	(1.08)	2.60	(0.98)	2.57	(1.20)	2.61	(0.76)
School engagement	0.09	(0.97)	0.11	(0.88)	0.18	(0.87)	-0.04	(1.03)
Base year science self efficacy	0.06	(0.99)	0.18	(0.94)	0.45	(0.92)	0.36	(0.88)
Occupational concentrator	0.13	(0.33)	0.58	(0.49)	0.98	(0.14)	1.00	(0.00)
School urbanicity	2.34	(1.13)	2.42	(1.10)	2.56	(1.11)	2.56	(1.06)
City	0.28	(0.45)	0.24	(0.43)	0.19	(0.40)	0.13	(0.34)
Suburb	0.34	(0.47)	0.36	(0.48)	0.36	(0.48)	0.47	(0.50)
Town	0.13	(0.34)	0.16	(0.36)	0.15	(0.36)	0.11	(0.32)
Rural	0.25	(0.43)	0.25	(0.43)	0.30	(0.46)	0.29	(0.46)
School control	1.27	(0.57)	1.13	(0.46)	1.02	(0.14)	1.00	(0.00)
Public	0.80	(0.40)	0.91	(0.28)	0.98	(0.14)	1.00	(0.00)
Catholic	0.13	(0.34)	0.04	(0.19)	0.02	(0.14)	0.00	(0.00)
Other private	0.07	(0.25)	0.05	(0.21)	0.00	(0.00)	0.00	(0.00)
> 50% on free lunch	0.27	(0.44)	0.32	(0.47)	0.29	(0.46)	0.27	(0.45)
> 10% 9th grade repeaters	0.19	(0.39)	0.21	(0.41)	0.18	(0.38)	0.23	(0.42)
Has program to encourage URM into STEM	0.30	(0.46)	0.33	(0.47)	0.34	(0.48)	0.20	(0.41)
Has program to inform parents of STEM careers	0.41	(0.49)	0.44	(0.50)	0.49	(0.50)	0.42	(0.50)
Importance of math placement tests	3.09	(1.09)	3.03	(1.09)	3.02	(1.16)	2.79	(1.14)
Not at all important	0.15	(0.36)	0.16	(0.36)	0.17	(0.38)	0.18	(0.39)
A little important	0.09	(0.29)	0.11	(0.31)	0.14	(0.35)	0.21	(0.42)
Somewhat important	0.26	(0.44)	0.28	(0.45)	0.18	(0.39)	0.24	(0.44)
Very important	0.49	(0.50)	0.45	(0.50)	0.51	(0.50)	0.36	(0.49)
Observations	10850		900		150		50	

Estimates, then, are after controlling for all observed and unobserved school-related factors potentially confounding the association between the self-efficacy measures and applied STEM coursework. Our school fixed effects model was expressed as:

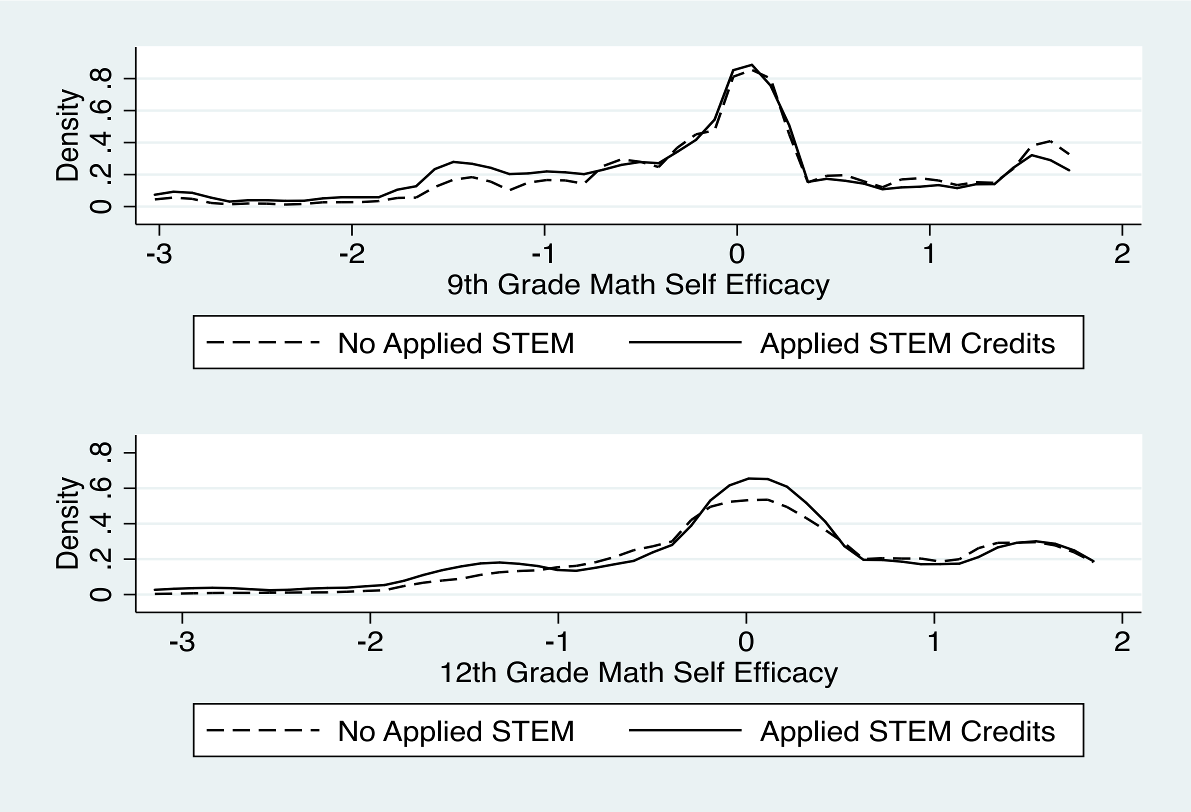
$$Eq\ 2\colon Y_{is} = \alpha + \beta AS_i + \theta Z_i + \gamma_s + \varepsilon_{is}$$

where the terms and regression parameters are identical to equation 1, except for the addition of γ, which is school fixed effects. While the coefficients associated with this parameter are not reported, we indicate in the estimate tables that follow whenever we included school fixed effects terms in our models. Like before, the error term, ε, was clustered at the school level.

Results

We began our analysis by visually inspecting for differences among applied STEM and non-applied STEM coursetakers in math and science self-efficacy among students in the analytic sample. Figure 1 suggests that in the 9th grade, students who did and did not earn credits in applied STEM were nearly identical in their reported levels of math self-efficacy. However, Figure 1 suggests that there was a greater degree of variation among these two groups of students in the 11th grade.

Figure 1: 9th and 11th grade math self-efficacy of applied STEM and non-applied STEM coursetakers



In turn Figure 2 suggests a similar pattern. Students in the analytic sample who did and did not earn credits in applied STEM were more similar, on average, in their reported levels of science self-efficacy in the 9th grade than they were in the 11th grade. We proceeded with our statistical analyses to confirm the general trends we noticed after visually inspecting these relationships.

Figure 2: 9th and 11th grade science self-efficacy of applied STEM and non-applied STEM coursetakers

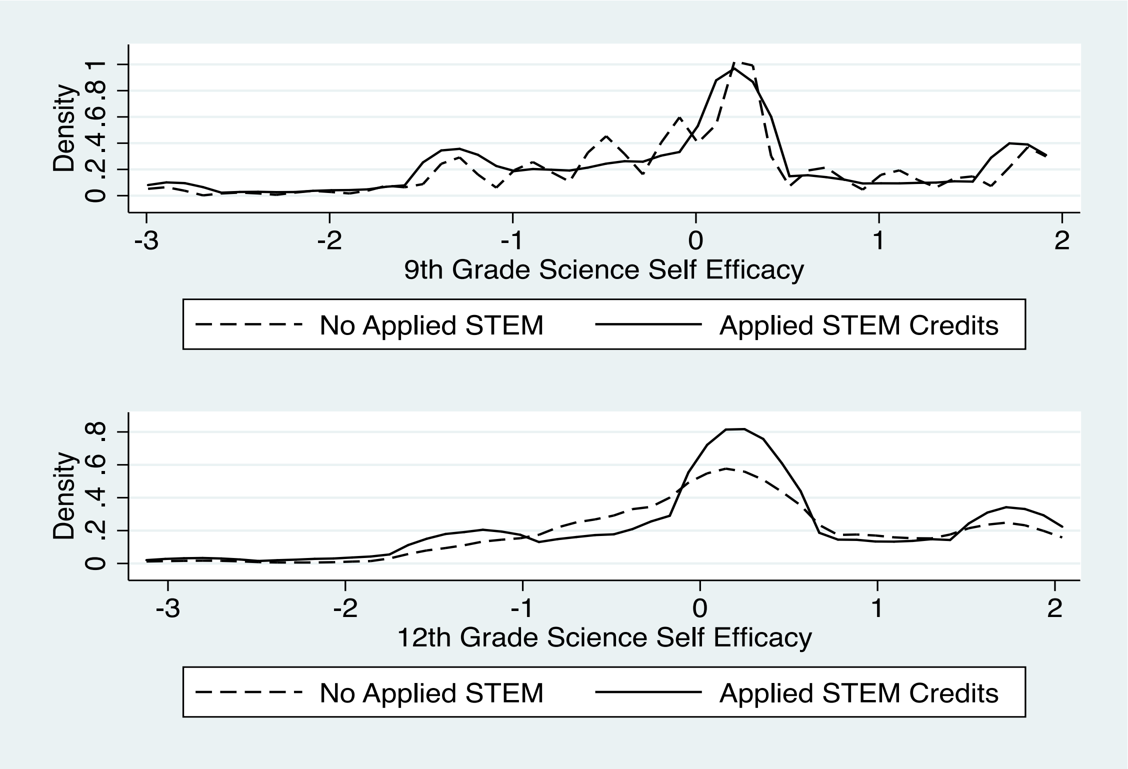


Table 3 contains the parameter estimates for the regression models of math self-efficacy on applied STEM coursework. We report the estimates of 6 models. The first 3 regression models were estimated with the complete set of control variables listed in Table 1. Model 1 used the total number of applied STEM credits earned as the main predictor variable, Model 2 used the total number of CIS credits earned as the main predictor variable and Model 3 used the total number of E&T credits earned as the main predictor variable. Models 4 through 6 also contained the full set of controls and the same ordering of main predictors, but unlike models 1 through 3, these new models also included school fixed effects. For parsimony, and because there was significant overlap, we will focus our description of the results of the estimates produced by the more robust fixed effects models.

Table 3

Regression Models of Math Self Efficacy

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Applied STEM Credits	0.03*** (0.01)			0.04*** (0.01)		
CIS Credits		0.02 (0.01)			0.02* (0.01)	
E&T Credits			0.05*** (0.01)			0.06*** (0.01)
Observations	22605	19700	19700	25206	21928	21928
Controls	Yes	Yes	Yes	Yes	Yes	Yes
School fixed Effects	No	No	No	Yes	Yes	Yes

Note: Standard errors in parentheses; *p<.05, **p<.01, ***p<.001

Looking at Table 3, we see that the fixed effects model which used the continuous measure of applied STEM credits earned in high school indicated that credits earned in applied STEM coursework were positively associated with increases in math self-efficacy. More specifically, our estimates suggested that a one credit increase in applied STEM was associated with an increase of 0.04 standard deviation units in math self-efficacy. When we disaggregated applied STEM credits into those earned in CIS and those earned in E&T, we saw that both CIS and E&T coursework were individually associated with increases in math self-efficacy. However, estimates suggested that for every credit earned in E&T coursework, we would expect an increase in 0.06 standard deviation units in math self-efficacy. This was compared to an increase of 0.02 standard deviation units for CIS coursework.

Table 4 contains the parameter estimates of the regression models of science self-efficacy on applied STEM coursework. Again, while we report the estimates of 6 models we will focus our discussion on the estimates produced by models 4 through 6. Like Table 3, the estimates in Table 4 produced by the regression model using the continuous measure of applied STEM indicated that for every credit a student earned in applied STEM, we would expect his or her science self-efficacy to increase by 0.03 standard deviation units. Disaggregating applied STEM into CIS and E&T, we see that a one-unit increase in CIS credit accrual was associated with increase in science self-efficacy of 0.02 standard deviation units. Furthermore, we would expect to see an increase science self-efficacy of 0.04 standard deviation units for every credit a student earned in E&T coursework. In sum, the results listed in Tables 2 and 3 suggested that even after controlling for baseline self-efficacy levels and a variety of a student and school-level factors, earning credits in applied STEM throughout high school was predictive of increases in both math and science self-efficacy.

Table 4

Regression Models of Science Self Efficacy

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Applied STEM Credits	0.03** (0.01)			0.03*** (0.01)		
CIS Credits		0.02 (0.01)			0.02* (0.01)	
E&T Credits			0.04** (0.01)			0.04*** (0.01)
Observations	22605	19700	19700	25206	21928	21928
Controls	Yes	Yes	Yes	Yes	Yes	Yes
School fixed Effects	No	No	No	Yes	Yes	Yes

Note: Standard errors in parentheses; *p<.05, **p<.01, ***p<.001

Differences by Gender and Disability Status

Because prior research has indicated that females are less likely to enroll in and benefit from applied STEM courses (Sublett & Gottfried, 2017), we wanted to examine the degree to which the relationship between applied STEM coursework and the self-efficacy outcomes varied between male and female students in our HSLS:09 analytic sample. Previous research has also illustrated that applied STEM coursework has differential impacts for students with disabilities (SWDs) and those without (Gottfried & Sublett, 2017). Consequently, in addition to looking for differences in gender, we sought to test for similar heterogeneity among students with and without disabilities in our analytic sample.

Table 5 contains the estimates of regression models predicting math and science self-efficacy from applied STEM coursework for female students in the analytic sample. All male students were dropped from these models. By contrast, Table 6 contains the estimates of identical regression models predicting math and science self-efficacy from applied STEM coursework for only males in the analytic sample. All female students were dropped from these models. The estimates in Table 5 suggest that completing applied STEM coursework was not associated with statistically significant increases or decreases in math or science self-efficacy for female high school students.

Table 5

Regression Models of Math and Science Self Efficacy - Females

	Math self-efficacy					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Applied STEM Credits	0.01 (0.02)			0.02 (0.02)		
CIS Credits		0.01 (0.02)			0.01 (0.02)	
E&T Credits			0.03 (0.03)			0.03 (0.04)
	Science self-efficacy					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Applied STEM Credits	-0.00 (0.02)			0.02 (0.02)		
CIS Credits		-0.01 (0.02)			-0.00 (0.02)	
E&T Credits			0.04 (0.04)			0.07 (0.04)
Observations	11000	9659	9659	12292	10779	10779
Controls	Yes	Yes	Yes	Yes	Yes	Yes
School fixed Effects	No	No	No	Yes	Yes	Yes

Note: Standard errors in parentheses; *p<.05, **p<.01, ***p<.001

On the other hand, Table 6 illustrates that applied STEM coursework was positively associated with increases in both math and science self-efficacy for males. In more detail, one applied STEM credit was associated with an increase of 0.04 standard deviation units in math self-efficacy among males. Courses in engineering and technology (E&T) were associated with greater increases in math self-efficacy (0.06) relative to courses in CIS (0.02).

Table 6

Regression Models of Math and Science Self Efficacy - Males

	Math self-efficacy					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Applied STEM Credits	0.04*** (0.01)			0.04*** (0.01)		
CIS Credits		0.02 (0.01)			0.02* (0.01)	
E&T Credits			0.06*** (0.01)			0.06*** (0.01)
	Science self-efficacy					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Applied STEM Credits	0.03** (0.01)			0.03*** (0.01)		
CIS Credits		0.03* (0.01)			0.02* (0.01)	
E&T Credits			0.03* (0.01)			0.04*** (0.01)
Observations	11605	11149	11149	12914	1114	11149
Controls	Yes	Yes	Yes	Yes	Yes	Yes
School fixed Effects	No	No	No	Yes	Yes	Yes

Note: Standard errors in parentheses; *p<.05, **p<.01, ***p<.001

With regard to science self-efficacy, the largest association between applied STEM and increases in science self-efficacy was with E&T courses (0.04), but even the aggregated applied STEM predictor was statistically significant and associated with an increase of 0.03 standard deviation units in science self-efficacy for every credit earned in applied STEM. In sum, the results contained in Tables 4 and 5 suggest that applied STEM coursework relates to increases in both math and science self-efficacy differentially by gender, with only male high school students showing statistically significant gains in self-efficacy.

Table 7 contains the estimates of the regression models predicting math and science self-efficacy for SWDs in our analytic sample. HSLS:09 participants were included in these regression models if they had a formalized IEP in the base year of HSLS:09 data collection. Looking at the estimates in the Table 7, we see that applied STEM coursework was not statistically associated with math self-efficacy for SWDs in our sample. Interestingly, credits in E&T courses were associated with relatively large increases in science self-efficacy among SWDs in our sample (i.e., 0.12 standard deviation units). However, when we controlled for all observed and unobserved school factors this association was no longer statistically significant. This suggests that between-school variation in, for example, resources or staffing or educational programs mediates the relationship between applied STEM course completion and increases in science self-efficacy among SWDs, such that when between-school variation is controlled for or held constant, students with disabilities do not experience gains in science self-efficacy that are statistically different from students in the general population who take similar classes.

Table 7

Regression Models of Math and Science Self Efficacy - SWDs

	Math self-efficacy					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Applied STEM Credits	0.03 (0.02)			0.04 (0.04)		
CIS Credits		0.02 (0.03)			0.01 (0.05)	
E&T Credits			0.06 (0.04)			0.05 (0.06)
	Science self-efficacy					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Applied STEM Credits	0.04 (0.03)			0.06 (0.04)		
CIS Credits		0.00 (0.04)			0.05 (0.05)	
E&T Credits			0.12** (0.04)			0.07 (0.06)
Observations	2003	1678	1678	2297	1925	1925
Controls	Yes	Yes	Yes	Yes	Yes	Yes
School fixed Effects	No	No	No	Yes	Yes	Yes

Note: Standard errors in parentheses; *p<.05, **p<.01, ***p<.001

In contrast to SWDs in our sample, students without disabilities who earned credits in applied STEM in high school experienced statistically significant gains in both math and science self-efficacy, even after controlling for between-school variation (i.e., school fixed effects). Looking now at Table 8, in terms of math self-efficacy, our estimates suggested that a one unit increase in applied STEM credits was associated with an increase of 0.04 standard deviation units in math self-efficacy among the general population of students. Credits earned in CIS courses were not associated with math self-efficacy at conventional levels of statistical significance. However, estimates revealed that a credit earned in E&T coursework was associated with an increase of 0.06 standard deviation units in math self-efficacy. A similar pattern was found with science self-efficacy. Applied STEM credits (both CIS and E&T) were associated with gains in science self-efficacy ($\beta = 0.03$). There was a non-significant association between science self-efficacy and CIS coursework. However, E&T credits were associated with an increase of 0.04 standard deviation units in science self-efficacy among students in the general popualtion. In sum, our results suggested that applied STEM coursework was not statistically predictive of increases or decreases in math or science self-efficacy among SWDs in our sample after accounting for between-school variation. On the other hand, applied STEM credits, particularly those earned from E&T courses, were associated with statistically significant gains in both math and science self-efficacy for students in the general population.

Table 8

Regression Models of Math and Science Self Efficacy - General Population

	Math self-efficacy					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Applied STEM Credits	0.03*** (0.01)			0.04*** (0.01)		
CIS Credits		0.02 (0.01)			0.02 (0.01)	
E&T Credits			0.05*** (0.01)			0.06*** (0.01)
	Science self-efficacy					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Applied STEM Credits	0.02** (0.01)			0.03*** (0.01)		
CIS Credits		0.02 (0.01)			0.02 (0.01)	
E&T Credits			0.03* (0.01)			0.04** (0.01)
Observations	20602	18022	18022	22909	20003	20003
Controls	Yes	Yes	Yes	Yes	Yes	Yes
School fixed Effects	No	No	No	Yes	Yes	Yes

Note: Standard errors in parentheses; *p<.05, **p<.01, ***p<.001

Discussion

Professional projections indicate that the demand for STEM interested and trained graduates will increase in the coming years (ACT, 2013; Bureau of Labor Statistics, 2013; Sargent Jr., 2014; Snyder, de Brey, & Dillow, 2016). The degree to which the US meets this demand will impact the economic vitality of the nation. Career and technical education (CTE) in high school is a known vehicle for introducing students to STEM and for increasing persistence in the STEM pipeline, from high school to college to career (Dougherty, 2016; Plasman & Gottfried, 2016). Thankfully, a number of United States policymakers have recognized this by continuing to fund the Carl D. Perkins legislation which supports many of the CTE program in the nation, including applied STEM courses in high school. As policymakers in the 115th Congress consider the reauthorization of this important legislation, it may be instructive for them to heed the findings of the current study.

This empirical analysis sought to contribute to the understanding of applied STEM coursework in high school by addressing a gap in the existing literature. Previous research has revealed that applied STEM courses are positively related to increased STEM achievement, odds of choosing a STEM major, and reduced odds of dropping out from high school (Dougherty, 2016; Gottfried, Bozick, Rose, & Moore, 2016; Plasman & Gottfried, 2016). What is not known, however, is the degree to is the degree to which these courses may or may not relate to students' self-efficacy beliefs in math and science. We feel this was an important research gap to fill because perceptions of self-efficacy are integral to student success. The results of the current study revealed three important conclusions, each of which has salient policy implications.

The first conclusion from the current study was that even after controlling for a rich set of covariates related to students' demographic and academic backgrounds and while also holding all observed and unobserved school-level factors constant, earning credits in applied STEM was predictive of increases in both math and science self-efficacy in high school. Our estimates revealed that we would expect students' reported levels of math self-efficacy to increase by an average of 0.04 standard deviation units for every credit students earned in applied STEM. We would also expect students' science self-efficacy levels to increase by 0.03 standard deviation units. Interestingly, our models suggested that courses in E&T were associated with greater gains in both self-efficacy measures relative to CIS courses. This may indicate that E&T courses are particularly valuable for boosting high school students' math and science self-efficacy, though it is important to note that our empirical models are only correlational and do not imply a causal link between applied STEM and self-efficacy. Nevertheless, proponents of engineering education will be buoyed by the findings of this study which hint at the potential for courses in E&T to play a part in elevating STEM interest and self-efficacy in high school students.

The second conclusion to be gleaned from the current study pertains to the heterogeneous nature of the associations we first reported in Tables 3 and 4. In subsequent fully-interacted models, our results illustrated that applied STEM credit accrual was not associated with changes in math or science self-efficacy at a statistically significant level among female students. By contrast, such credits were predictive of statistically significant increases in both math and science self-efficacy among males. These findings align with previous investigations into applied STEM coursetaking and provide further evidence of a gender disparity in STEM wherein males appear to disproportionately enroll in and benefit from STEM coursework in high school (Sublett & Gottfried, 2017). This has the potential for spillover effects that bleed into postsecondary education and, eventually into the STEM labor market. It was not possible for us to identify the mechanism underlying the null associations we reported for women in our sample and it is beyond our abilities to speculate. However, future research should investigate this finding, as it appears in line with findings from other studies and is potentially indicative a troubling pattern. Women continue to be underrepresented in STEM fields of study and in STEM careers. Applied STEM courses have the potential to increase and diversify the pool of STEM-interested students in the nation, yet we do not see evidence that females are enrolling in these courses in great numbers. Furthermore, those females who do enroll do not appear to be experiencing boosts in self-efficacy from having done so. This seems to us as a potential area of improvement, one that should be addressed at the policy level.

The third conclusion pertains to the differential relationships between applied STEM coursework and the self-efficacy outcomes among SWDs and the general population of students. It appeared from our estimates that, as previous research has indicated, SWDs interact with applied STEM courses differently than students in the general population. Gottfried and Sublett (2017) showed that SWDs in the Educational Longitudinal Study of 2002 (ELS:2002), the precursor to HSLS:09, were less likely to enroll in applied STEM courses relative to general popoluation students. The SWDs who did enroll in applied STEM did not see gains in math achievement, as measured by standardized test performance, nor did the SWDs who took applied

STEM experience greater odds of enrolling in advanced STEM coursework by high school graduation. Our results reinforce the notion that SWDs do not experience the same associations with applied STEM coursework as their general population counterparts do. In particular, our results illustrated SWDs did not have statistically significant changes in math or science self-efficacy. Importantly, SWDs who enrolled in applied STEM courses were not *hampered* by applied STEM participation. Also, it is important to note a degree of sensitivity in our statistical findings. When not accounting for all observed and unobserved school-factors, we observed a marked association between E&T credits and science self-efficacy in SWDs. Yet, when we included school fixed effects, this association was no longer statistically meaningful. The temptation is to ignore the statistically significant findings produced by the model without school fixed effects. However, we believe there is reason for further reflection here. Students with disabilities are precisely the kind of students we would theorize to benefit from applied STEM coursework. As we previously mentioned, these courses are strikingly different from academic STEM courses in that they stress the applicability of STEM concepts, prioritize active and engaged learning over text and lecture-based instruction. That our baseline regression model found a statistically significant increase in science self-efficacy associated with credits in E&T courses provides support for this theory. However, that this finding became non-significant after accounting for between-school variation also makes intuitive sense since research has long illustrated that schools vary in the kinds and qualities of programs and services they provide for SWDs.

The foregoing conclusions lead to two main policy recommendations. First, based on the findings of this study as well as the many rigorous studies preceding this one, we recommend lawmakers in the 115th Congress take action to reauthorize the Carl D. Perkins Career and Technical Improvement Act of 2006. It is encouraging that members of the House Education and the Workforce Committee recently approved a reauthorization bill. Yet, similar legislation was approved by the House of Representatives in 2016 but that particular bill never made it to the upper chamber. At a time when CTE is so prominently discussed in the nation and is so clearly important to the success of students and the nation’s economy, we hope that the new Congress will succeed in crafting bipartisan legislation in support of CTE and, in particular, applied STEM.

With that said, the findings of this study point to an area of concern, namely the disparities we and researchers before us observed along gender and disability lines. Previous iterations of Perkins focused on increasing the representation of "special populations" in CTE. And while the intent was to improve the education or prospects among unrepresented student groups, critics rightly pointed out that funneling select groups of students into vocationally oriented courses represented a potentially pernicious form of tracking. Fully aware of this danger, we do not argue for a return to the specific targeting of minority groups into CTE. However, we do suggest that policymakers consider ways in which current Perkins legislation does or does not incentivize participation of all student groups. Of course, the current analysis is unable to speak to other important factors that could be driving the disparities we observed. Future studies, then, may want to consider investigating the role of pedagogy in applied STEM coursework and how particular aspects of, for example, instruction or instructors may be contributing to the null associations we found among female and SWDs.

While the current study made great efforts to maximize external and internal validity by using a nationally representative data set and robust analytic models, the current study was limited in the number of ways. First, the current report presents the findings of correlational analyses. Even after controlling for a wide variety of student and school-level factors and potential confounds, the reported associations were not causal in nature. Ultimately, then, caution should be taken when interpreting the results.

The second limitation of the current study is that we were unable to break out or disaggregate students by disability status. Using the data we had available, we were unable to determine whether students with learning disabilities or students with physical disabilities interacted differentially with applied STEM coursework when it is quite possible (and even plausible) that suggest differential relationships exist. Future research with access to data with more nuanced information around disability status should further investigate the findings we report here.

Finally, we were unable to speak to the curriculum or pedagogy students in our analytic sample were exposed to in their applied STEM courses. This was a limitation with our data that extends to the generalizability of our findings. Without knowing how these courses were taught and the potential variation in pedagogy from classroom to classroom, it remains an open question if the relationship between applied STEM and self-efficacy that we observed was or was not a potential fabrication resulting from, even partially, unobserved variation in teaching style or curriculum. Future studies with access to local data sources should prioritize this as an area of future research.

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