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Do Career-Engaging Courses Engage Low-Income Students?

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Encouraging school engagement is crucial to promoting positive outcomes for high school students. One potential means to promote school engagement may be through career and technical education (CTE) coursework, which is specifically designed to be educationally engaging, particularly for vulnerable populations such as those from low-income backgrounds. Yet, little is known about whether these courses do in fact link to higher school engagement. Through analysis of the High School Longitudinal Study of 2009—a nationally representative data set—we explored the link between STEM-focused CTE (STEM-CTE) coursetaking and school engagement for low-income students. To do so, we employed an instrumental variable estimation technique and found that taking STEM-CTE courses related to higher school engagement for low-income students. We conclude with a discussion of implications for students, practitioners, and policymakers.

Keywords: *career and technical education, secondary school, low-income students, engagement*

School engagement links to numerous positive student outcomes: school performance, increased probability of high school graduation, lower chances of illicit activity, higher odds of employment, and fewer behavioral problems (Broadhurst et al., 2005; Gershenson et al., 2017; Goodman, 2014; Kane, 2006; Rumberger, 1995). These consequences fall disproportionately on low-income students (Rumberger & Rotermund, 2012). Although some prior work has identified the role of coursework in promoting school engagement (Fredricks et al., 2004; National Research Council and Institute of Medicine, 2004; Rumberger & Rotermund, 2012), little attention has been paid to whether career-focused courses, specifically designed to boost school engagement, make a difference. We address this issue by documenting the role of science, technology, engineering, and mathematics career and technical education (i.e., STEM-CTE) courses in improving school engagement among low-income high school students.

What Are STEM-CTE Courses?

CTE courses are governed by the Carl D. Perkins Career and Technical Education Act, which represents a concerted effort by the Federal government to help students relate their high school experiences to college and career opportunities (Brand et al., 2013). In particular, the 2006 iteration of the Perkins Act ("Perkins IV") was a critical turning point in high school career coursetaking—emphasizing career trajectories rather than "vocational" courses. Through Perkins IV, CTE courses were redesigned to provide "competency-based applied learning that contributes to the academic knowledge, higher-order reasoning and problem-solving skills, technical skills and occupation-specific skills" (Carl D. Perkins Career and Technical Education Act, p. 4). One goal of the act was to develop career-related skillsets for students with a wide range of ability levels and highlight the relevance of high school coursework for success in college and later in career (Gottfried et al., 2014).

Perkins IV emphasized STEM-related course content—that is, "STEM-CTE." True to the fourth iteration of the Perkins Act, STEM-CTE courses focus on applying math and science skills in practically relevant ways, and they emphasize the relevance of academic math and science concepts to college and career experiences by incorporating "hands-on" quantitative reasoning, logic, and problem-solving skills. These courses assume that students may better learn STEM-based skills and procedures through real-world tasks rather than through theory, abstraction, and content comprehension typical of traditional STEM courses.

There are two strands of STEM-CTE: Engineering Technology and Information Technology. Engineering Technology could lead to careers in engineering analysis and digital electronics, while Information Technology courses provide skills for careers in networking technologies and Java programming. Though some states count computer science toward graduation requirements, STEM-CTE courses are neither designed nor intended to supplant traditional, academic math and science courses. Rather, STEM-CTE courses are designed to complement traditional math and science courses and should serve to reinforce academic knowledge (Bozick & Dalton, 2013; Shifrer & Callahan, 2010). Specifically, Bozick and Dalton (2013) found compelling evidence that students CTE participants did not compromise their overall math achievement by the end of high school. Furthermore, Plasman and Gottfried (2018) identified a STEM-CTE link with improved math achievement for diverse learners such as those with learning disabilities. Gottfried (2015) found evidence that students who enrolled in STEM-CTE courses were more likely to enroll in advanced academic math and science coursework than non-STEM-CTE students.

Perkins IV had two particularly important and relevant emphases regarding student groups and targeted areas of study. First, low-income students—identified in Perkins IV as "individuals from economically disadvantaged families"—were targeted to receive CTE programming to prepare them for high-skill, high-wage, and high-demand careers. Second, Perkins IV identified a need for enhanced STEM instruction to provide students with academic and career and technical skills to meet the increased demand for workers in STEM fields (Sublett, 2016). Taken together, policymakers made it clear that there is a need to increase the participation of low-income students in STEM-CTE coursework (Bell et al., 2017; Bragg et al., 2006).

Our study sits at the nexus of these issues: increased focus on low-income students' participation in CTE courses, increased attention paid to STEM-CTE in particular, and orientation of CTE toward making coursework more relevant to the "real world." As such, we focus on STEM-CTE coursetaking in high school and its link to low-income students' school engagement and interest in STEM. Though this connection has not been studied for STEM-CTE courses in particular, current research indicates that when high school coursework is more practically relevant, students' school engagement increases (Battistich et al., 2004; Dixon et al., 2011; Stone & Lewis, 2012). This relationship may be particularly salient for low-income students (Hyslop & Imperatore, 2013). Given the potential yet underexplored importance of STEM-CTE coursework for low-income students' school engagement, we asked the following research questions:

Research Question 1: Do students who participate in STEM-CTE courses exhibit higher levels of school engagement than nonparticipants?

Research Question 2: Do students who participate in STEM-CTE courses exhibit higher measured interest in STEM subjects than nonparticipants?

Research Question 3: Do any observed relationships between STEM-CTE and school engagement and interest in STEM vary for a key subgroup identified by Perkins IV—that is, low-income students?

The answers to these questions are valuable to CTE policy goals for several reasons. First, the policy emphasis on STEM-CTE courses for students from low-income backgrounds warrants an examination of the benefits of those courses for that population of students. Second, given the additional emphasis on making STEM-CTE courses more engaging for high school students (Brand et al., 2013), no one has examined whether these courses link with higher school engagement.

To be clear, we focus specifically on school engagement defined as students' adherence to norms and rules of a school (Fredricks et al., 2004). This type of school engagement is often referred to as behavioral school engagement (Fredricks et al., 2004), as it captures students' school-going behaviors: showing up late to class, skipping class, missing school, receiving in-school suspensions, and showing up unprepared. Based on this commonly employed definition, if students see the relevance of school, they may be more likely to conform to traditional norms and rules like showing up on time and being prepared for class (Xu, 2011).

That said, we acknowledge that school engagement is multidimensional (Fredricks et al., 2004). Scholars tend to study three dimensions of engagement: behavioral, emotional, and cognitive (Fredricks et al., 2004). In many ways, the focus of our study on one type of school engagement—that is, behavioral—is the most straightforward to measure empirically because it encompasses directly observable school-going behaviors that indicate a student's commitment to their schooling (Fredricks et al., 2004). More so, scholars have often focused on the study of behavioral school engagement because of its strong links to positive academic outcomes for students, and its relationship with drop-out prevention (Fredricks et al., 2004). Hence for the remainder of this study, our focus on school engagement is behavioral school engagement, though for simplicity throughout this study, we refer to this type of engagement as school engagement.

School engagement has been understudied in the general CTE field, which is surprising given CTE courses are intended to engage students in educational content. Yet, fostering school engagement has been the focus of numerous policies, programs, and initiatives directed at improving outcomes in high school and beyond (Hooley et al., 2011; Shernoff et al., 2003). This drive stems from a growing body of literature indicating students who exhibit higher levels of school engagement have higher odds of high school completion, fewer mental health issues, and better academic achievement (Bond et al., 2007; Rumberger, 2011; Rumberger & Rotermund, 2012). If taking STEM-CTE courses links to stronger school engagement for low-income students, our empirical evidence may help policy makers and educators improve access to STEM-CTE courses in schools with large low-income student populations.

Framework: STEM-CTE Coursetaking and School Engagement

Previous work by Gottfried et al. (2014) exploring the connections between STEM-CTE coursework and various outcomes established a theoretical framing connecting high school STEM-CTE coursetaking with student success. This framework includes three prongs: academic reinforcement, new skill building, and relevance.

Academic reinforcement is important because STEM-CTE courses support traditional math and science courses (Bozick & Dalton, 2013; Shifrer & Callahan, 2010), much like CTE in general was envisioned to supplement traditional academic courses (Dougherty, 2018). As a result, STEM-CTE courses provide students opportunities to reinforce academic knowledge learned in more traditional courses. Per Stone et al. (2008), extra time spent on math and science concepts via applied learning can improve achievement and may be critical in encouraging students to remain involved with school learning (Lessard et al., 2008).

Yet, STEM-CTE courses do more than reinforce STEM content from other courses. They also promote new skill building (Dougherty, 2018; Plasman & Gottfried, 2018; Stone et al., 2008). In STEM-CTE courses, students learn how traditional math and science concepts are intertwined and consequently how to use these concepts and skills to address practical problems. When high school students build skills across the theoretical focus of traditional courses and applied content, they are better positioned to develop skills for success in postsecondary education and career (Stone et al., 2008; Stone & Lewis, 2012; Symonds et al., 2011). STEM-CTE courses have been distinguished from traditional STEM courses not in difficulty or access based on student ability, but rather in how the development of new skills geared at addressing STEM challenges might further engage students in the STEM pipeline (Gottfried et al., 2014; National Research Council, 2011).

Finally, STEM-CTE coursetaking may directly link to higher school engagement and STEM-specific interests through exposure to the practical relevance of the material (Gottfried et al., 2014; Kelly & Price, 2009). Students have displayed higher levels of school engagement when courses include relevant content to the real world (Battistich et al., 2004; Dixon et al., 2011; Kelly & Price, 2009; Stone & Lewis, 2012), and we hypothesize this to be true for STEM-CTE as well. Exposure to the practical content knowledge offered in STEM-CTE courses might help students better engage with school for three reasons specific to the goals of Perkins IV. First, career-related courses familiarize students with new career areas, and linking course content to career—a focal tenet of CTE—fosters school engagement (Castellano et al., 2012; Mobley et al., 2011). Second, career-related courses can help students recognize the types of specific skills and knowledge needed in STEM-CTE jobs, thereby motivating students to engage with school to garner necessary knowledge and skillsets (Stone & Lewis, 2012). Finally, as described by Kelly and Price (2009), CTE courses may improve feelings of self-worth from the experience of being in these courses, ultimately improving school engagement.

Thus, each of these three prongs illustrates a potential path by which STEM-CTE coursetaking might increase students' school engagement. Although there is a theoretical expectation that STEM-CTE should relate directly to school engagement, few studies empirically explore this relationship. However, there are several studies in CTE and non-CTE literature that connect coursetaking to proxy measures of school engagement. For example, there is a connection between course relevance and school engagement in the case of ethnic studies courses, where a culturally relevant curriculum increased attendance and GPA among academically at-risk high school students (Dee & Penner, 2017). We also see evidence of a relationship between participation in school-based career interest activities and job readiness training and school engagement as measured by attendance and dropout rates (National Dropout Prevention Center/Network, 2014).

These connections also play out with respect to CTE coursetaking. Plasman and Gottfried (2020) found high school students who took STEM-CTE courses had higher school attendance—one aspect of school engagement, though not complete. Hemelt et al. (2019) found evidence that students in career academies had higher attendance rates than students in traditional high schools, helping explain lower rates of dropping out of high school, another aspect school engagement. Dougherty (2018) and Bonilla (2020) also found career-oriented programming linked with lower high school dropout rates. Although this research shows evidence of the relationship between CTE coursework and specific elements of school engagement, there is little empirical evidence on the relationship between STEM-CTE coursetaking and a more complete school engagement measure.

Low-Income Students. Although there is no known evidence about whether STEM-CTE can support low-income students' school engagement, we hypothesize that STEM-CTE courses might especially benefit low-income students. Previous work on CTE broadly links participation by low-income students with high school graduation (Dougherty, 2018). This work identifies that effects of CTE coursetaking are greater for low-income students than their higher income peers.

We hypothesize that the framework described above becomes particularly relevant for low-income students' school engagement in the following two unique ways. First, students from lower income families are less likely to have a parent or caregiver trained in a STEM field (Yelamarthi & Mawasha, 2008), thereby reducing home-based exposure to practical STEM-work or adults to help promote STEM interests. Given STEM-CTE courses are school-based opportunities to reinforce content and develop new skills (Brand et al., 2013; Schargel & Smink, 2001), low-income students could gain a broader range of these STEM skills as they develop interests from within the school context (Brand et al., 2013).

Second, STEM-CTE courses were in-part designed to help students see the relevance and importance of high school (Brand et al., 2013; Oakes & Saunders, 2008; Partnership for 21st-Century Skills et al., 2010). For low-income students who do not often have outside-of-school support, STEM role models, or guidance in terms of educational pursuits, STEM-CTE may serve as one school-based pathway to engage students in education. In fact, the more students engage in activities that demonstrate the relevance of high school coursework on longer term outcomes, the more likely they are to remain in these activities. Hence, because STEM-CTE courses lie at the nexus between traditional and applied content and “real-world” relevance (Brand et al., 2013), taking STEM-CTE courses might provide school-based avenues for low-income students to develop an understanding of the importance of being in high school and remaining engaged (Stone & Lewis, 2012).

The interest in and efficacy of STEM-CTE courses for low-income students (or any student, for that matter) would of course depend on school context. As Bozick and Dalton (2013) describe, the types of CTE courses in a school might depend on not only school structure such as a career-focused high school or a STEM-themed high school but also on the school’s physical context and local labor markets (Dougherty, 2018; Levesque et al., 2000). These structures would consequently suggest that students might differently select into STEM-CTE courses—or have a different array of STEM-CTE course options—based on school structure, which may vary on individual, family, and neighborhood resources (Brand et al., 2013). Similarly, schools might have different capacities for scheduling, advising, and career services (Bozick & Dalton, 2013), hence differentially affecting lower income students if they are educated in lower resourced schools. In other words, students do not select into CTE courses randomly much like they do not randomly select into schools (Lucas, 1999). Therefore, these issues about STEM-CTE course offerings and course participation motivate our estimation strategy, as contexts, settings, and motivations are often difficult to observe.

STEM-CTE: Empirical Background

Without taking into account individual differences like income level, there is evidence that STEM-CTE participation has benefits for high school students in general. First, STEM-CTE coursetaking can be a pathway to traditional STEM coursework: STEM-CTE coursework in 9th and 10th grades is associated with higher odds of later advanced traditional math and science coursetaking (Gottfried, 2015). STEM-CTE coursetaking is also associated with higher 12th-grade math achievement (Gottfried et al., 2014), and math and science self-efficacy (Sublett & Plasman, 2017). STEM-CTE also links to higher odds of selecting a STEM major in college (Gottfried & Bozick, 2016), and STEM-CTE concentrators in high school earned significantly more in their jobs than students who concentrated in other clusters (Dougherty, 2016).

STEM-CTE coursetaking also has specific benefits for subgroups underrepresented in STEM. For example, STEM-CTE coursetaking is associated with increased high school graduation rates among students with learning disabilities (Plasman & Gottfried, 2018). Additionally, Gottfried and Plasman (2018a) observed potential benefits of STEM-CTE courses for women such that female students who participated in Engineering Technology coursework experienced larger benefits related to earning a postsecondary credential in engineering than did male students. This finding implies there may be differential benefits for specific subsets of students, whether by disability status, gender, or in this case, low-income status.

Low-Income Students and STEM-CTE. There is little work focused on the potential benefits of any type of CTE coursework for students from lower income backgrounds. We do know, however, that the benefits of any CTE coursetaking in high school are larger for low-income students than for their higher income peers in relation to odds of high school graduation (Dougherty, 2018; Dougherty & Harbaugh MacDonald, 2019). Furthermore, low-income students are significantly more at risk of not completing high school than higher income students (Schoeneberger, 2012), suggesting that finding ways to better engage and encourage these students to come to school may have wide-ranging benefits (Kearney & Levine, 2016).

Given low-income students tend to be overrepresented in CTE courses in general, as well as STEM-CTE courses specifically (Sublett & Gottfried, 2017), the lack of research in this area is surprising given that many researchers have pointed out CTE may be effectively encourage success for students who may not otherwise graduate from high school or serve as a bridge to meaningful postsecondary education for students who would not otherwise have matriculated (Cullen et al., 2013; Kreisman & Stange, 2017). Though educational risk is not necessarily a direct mapping onto low-income constraints, there is some overlap and thus this helps provide insights into the potential of CTE coursetaking, particularly in the case of attendance—one component of school engagement—where the link with low-income status is explicit.

There also remains a lack of research specifically investigating the role of STEM-CTE for low-income students. This gap is surprising when considering exposure to STEM-CTE courses is important for secondary schooling and college and employment outcomes. Therefore, our research begins to carve out an understanding of the role of STEM-CTE courses on key school engagement outcomes for low-income students.

Method

Data Set Overview

To explore whether STEM-CTE coursetaking is associated with school engagement for low-income students, we relied on data from the High School Longitudinal Study of 2009 (HSLS). HSLS is a nationally representative, longitudinal data set compiled by the National Center for Education Statistics (NCES). This is the most current, nationally representative data set that includes measures on secondary students' coursetaking and school engagement. Base-year student surveys were conducted in the fall of 2009 when students first entered the ninth grade. NCES administered a follow-up survey in the spring of 2012 when most students were finishing 11th grade. NCES added high school transcript data and conducted another wave of data collection in 2013–2014—a year after expected high school graduation.

Because our study focused on coursetaking as our key independent measure, we relied extensively on the transcript data. This data includes records of every course taken by each student, grades received, and credits earned. In total, transcripts were collected for 87% of the full sample, and 93.5% of the low-income sample. Though there were slight differences between low-income students for whom a transcript was and was not available, the low percentage of missingness and the provision of transcript weights gave us confidence that results remain generalizable.

We standardized the measure of credits earned to Carnegie Units to allow for cross-school comparisons, such that one Carnegie Unit equates to a course taken for a 1-hour period every day for a full school year. Using provided course codes, we identified specific courses falling into the STEM-CTE category, as described below. We performed multiple checks to ensure the data was accurate—duplicate record identification, mismatches between credit earned and grade received, and compatibility between credits earned and school calendar (i.e., semester, trimester, quarter, etc.). We then merged the transcript data with base year and follow-up survey data to produce a complete representation of each student.

Throughout this article, we identify our population of interest, low-income students, as those students with family income less than twice the federal poverty threshold—a definition used by the National Center for Children in Poverty and the Working Poor Families Project using American Community Survey data (Jiang et al., 2015; Roberts et al., 2013). HSLS codes income with income-range bins, which did not allow for a direct observation of exact family income. Therefore, we used the upper limit of the income bin as the cutoff for poverty identification. As such, if the upper limit for an individual fell below the double poverty level cutoff, they were identified as low income.

For individuals with missing data, we employed a multiple imputation technique to impute 20 additional data sets as has been recommended in previous methodological research (Graham et al., 2007). In our analyses of math and science interest, we used the unimputed values of the outcomes. This method of multiple imputation, then deletion as described by Von Hippel (2007) has been identified as an appropriate strategy to improve the efficiency of estimates and when the imputation of the missing dependent variable may be problematic in some way, as is the case in our analyses of math and science interest where students were asked to respond with regard to the math or science class in which they were enrolled during the junior year of high school. The final analytic sample included students identified as low income who had nonmissing outcome data. After imputation, the final analytic sample included 19,980 total student observations with 8,380 low-income student observations. In accordance with NCES guidelines, all sample sizes are rounded to the nearest ten.

School Engagement

The first outcome of interest in this study was a school engagement composite created via principal component analysis by the NCES, including the following items collected at the end of 11th grade: times late to school; times skipped class; times missed school; times showed up to class without completed homework; times showed up to class without paper; times showed up to class without the course textbook; and whether a student ever received an in-school suspension (Ingels et al., 2015). In HSLS, this variable is labeled as a "scale of student's school engagement." The variable has been standardized with a mean of 0 and standardized deviation of 1. A higher score indicates a higher (and more desirable) level of school engagement.

Math and Science Interest

Two additional outcomes relate to student-expressed interest in mathematics and science coursework in the junior year. These composite variables were created by NCES, again through principal component analysis, using the following items collected both during the ninth and 11th grades: enjoyment of the [math/science] class; considers [math/science] class a waste of time; considers [math/science] class boring; [math/science] is a favorite subject; [math/science] is a least favorite subject; and whether broadly enjoy [math/science]. In HSLS, these variables are labeled as "math course interest" and "science course interest." These items specifically asked students to refer to the math or science class in which they were enrolled at the time of the survey. As such, students who were not enrolled in math or science coursework during the junior year are excluded from corresponding analyses. As with engagement, these composite variables are standardized, and a higher score indicates greater interest.

STEM-CTE Coursetaking

Our key predictor was the number of STEM-CTE credits earned during the junior year of high school. NCES includes standardized course codes for every course in which a student participated in high school. These codes allow us to first identify which courses fell into the broad CTE category as identified in the high school course taxonomy (Bradby & Hudson, 2007). Using these codes, we coded courses falling into the STEM-CTE category as identified in prior research (Bozick & Dalton, 2013; Bradby & Hudson, 2007). The two CTE clusters making up this broader STEM-CTE category include information technology and engineering technology. Information technology courses focus on the design, development, support, and management of computers and computer systems. Examples of courses in this cluster include C++ programming and data processing. Engineering technology courses focus on providing students with skills to connect the abstract concepts and theories of traditional math and science to more practical problems. Such classes include robotics and aerospace technology.

We measured STEM-CTE coursetaking by earned credits. We chose to focus on the number of units instead of the number of courses to ensure we were making standardized comparisons across different schools. Throughout this study, any reference to STEM-CTE coursetaking refers to STEM-CTE earned credits. Across the full sample, approximately 14.1% of students earned at least some credit for STEM-CTE during junior year, while 14.7% of low-income students did so. Among STEM-CTE credit-earners, the mean number of earned credits was 0.93 (0.94 for low-income students).

Control Variables

We selected a wide variety of student- and school-level control variables based on prior research on STEM-CTE and school engagement (Allensworth & Easton, 2007; Balfanz & Byrnes, 2012; Dougherty, 2018; Plasman & Gottfried, 2020; Sublett, 2016). We present the descriptive statistics for each of our selected variables in Table 1 (see the appendix for HSLS variable names). As much as possible, we tried to include variables from the first follow-up (junior year) survey. If a certain variable was not available in the follow-up survey, we gathered the relevant information from the base-year survey. We also took certain variables—GPA, academic units, and non-STEM-CTE units—from the transcript files. Each variable is binary unless indicated otherwise.

Our control variables fell across three categories: sociodemographics, academic history and attitudes, and school characteristics. Sociodemographic data included gender, underrepresented minority status, family arrangement, and parent education. Academic history and attitudes included cumulative ninth- and 10th-grade GPA, academic untis (a sum of language arts, mathematics, social studies, science, fine arts, and foreign language units) through 11th grade, CTE units in other clusters (non-STEM-CTE) during junior year, individualized education plan status, English learner status, 9th-grade school engagement, and postsecondary expectations. We included other CTE coursework in our analyses to better isolate the specific STEM-CTE association with school engagement. We included early high school GPA as a proxy measure for overall achievement because of its predictive relationship to eventual high school success (Allensworth et al., 2014).

The final category of control variables focused on school characteristics. We included an indicator of whether the school is public or private, percentage of students eligible for free or reduced-price lunch, and percentage of students from racial/ethnic groups that are traditionally underrepresented in STEM fields, including Hispanic, African American, Native American, or students from two or more races (National Science Foundation, 2008). We also included measures of school climate (a higher score indicated a more desirable climate), and whether parental involvement is a problem at the school (a higher score on the latter variable indicated a more serious issue).

Analytic Approach

Baseline Model. To obtain a first estimate of the relationship between school engagement and STEM-CTE coursetaking, we employ the following baseline model:

$$Eng11_i = \beta_0 + \beta_1 STEMCTE_i + \beta_2 Eng9_i + \beta_3 X_i + \varepsilon_i. \quad (1)$$

In this equation, the outcome variable $Eng11_i$ represents student *i*'s school engagement measured during junior year of high school. $STEMCTE_i$ refers to the number of STEM-CTE credits completed during junior year, meaning that β_1 is the coefficient of interest. $Eng9_i$ represents the baseline measure of student engagement, and X_i is a vector of all the control variables identified in Table 1. Finally, ε_i represents the student-level error.

We use this same equation to estimate the relationship between STEM-CTE coursetaking and STEM interest, which we estimate separately for math and science. However, we include baseline levels of math or science interest—instead of baseline engagement—depending on the outcome of interest.

TABLE 1

Descriptive Statistics

Variable	Full sample, *M* (*SD*)	Low income, *M* (*SD*)	Mid/high income, *M* (*SD*)
11th-grade engagement	0.00 (1.00)	−0.02 (1.01)	0.01 (1.00)
11th-grade math interest	0.00 (1.00)	−0.04 (0.99)	0.02 (1.01)
11th-grade science interest	0.00 (1.00)	−0.08 (1.06)	0.06 (0.95)
11th-grade STEM-CTE credits	0.14 (0.36)	0.14 (0.37)	0.14 (0.39)
Sociodemographic variables			
Female	0.49 (0.50)	0.49 (0.50)	0.49 (0.50)
Underrepresented minority	0.42 (0.46)	0.51 (0.48)	0.33 (0.47)
Family arrangement			
Single parent	0.30 (0.42)	0.41 (0.49)	0.21 (0.40)
Both biological parents	0.56 (0.50)	0.44 (0.50)	0.64 (0.48)
Other parental arrangement	0.14 (0.32)	0.14 (0.35)	0.13 (0.34)
Highest parent education			
High school diploma or less	0.44 (0.44)	0.64 (0.43)	0.26 (0.44)
Some college	0.15 (0.36)	0.16 (0.37)	0.15 (0.35)
Bachelor’s degree or higher	0.40 (0.45)	0.20 (0.37)	0.60 (0.49)
Academic history and attitudes variables			
Academic units through junior year	16.49 (5.27)	15.94 (5.23)	17.80 (4.79)
STEM credits years 9–10	3.41 (1.18)	3.33 (1.14)	3.69 (0.99)
9th through 10th grade GPA	2.63 (0.86)	2.44 (0.87)	2.97 (0.74)
Additional CTE credits	0.55 (0.79)	0.64 (0.88)	0.53 (0.80)
Postsecondary expectations			
No college	0.19 (0.39)	0.25 (0.43)	0.11 (0.31)
2 years or less	0.07 (0.21)	0.09 (0.24)	0.05 (0.23)
4 years or more	0.73 (0.37)	0.65 (0.41)	0.84 (0.37)
Individualized education plan	0.20 (0.30)	0.25 (0.32)	0.17 (0.37)
English language learner	0.03 (0.15)	0.03 (0.17)	0.01 (0.11)
9th-grade engagement	0.00 (1.00)	−0.08 (1.01)	0.12 (0.95)
9th-grade math interest	0.00 (1.00)	−0.00 (1.01)	0.03 (0.99)
9th-grade science interest	0.00 (1.00)	−0.04 (0.99)	0.04 (1.00)
School variables			
Public high school	0.81 (0.38)	0.91 (0.28)	0.74 (0.43)
School climate	−0.40 (0.98)	−0.55 (0.93)	−0.25 (1.06)
Parental involvement	2.25 (0.92)	2.50 (0.89)	2.04 (0.94)
% English language learner	4.86 (8.62)	5.59 (9.49)	4.14 (7.68)
% Free or reduced-price lunch	33.41 (24.54)	42.23 (23.56)	26.51 (23.35)
% Underrepresented minorities	33.37 (27.48)	36.99 (29.50)	29.77 (25.98)
N	19,980	8,380	11,590

Note. All variables are binary unless otherwise noted—junior-year AS-CTE (0–4); junior-year engagement (−5.93 to 1.21); junior-year math interest (−2.02 to 1.94); junior-year science interest (−2.28 to 1.67); academic units through junior year (0–40); GPA (0–4); freshman-year engagement (−3.48 to 1.35); freshman-year math interest (−2.52 to 2.06); freshman-year science interest (−2.64 to 2.01); other CTE (0–8); school climate (−4.22 to 1.97); parental involvement (1–4); Percentage free or reduced-price lunch, underrepresented minorities (0–100). STEM = science, technology, engineering and mathematics; CTE = career and technical education.

In addition, we include a unique indicator of the number of STEM credits earned prior to junior year as this information is likely more relevant for our analysis of STEM interest than would be credits earned in other academic subjects.

Accounting for Omitted Variables: Instrumental Variable Estimation. While we account for key differences between students with a robust set of covariates, our estimates may still be biased by omitted variables associated with both STEM-CTE participation and/or our outcome of interest. The goal in our instrumental variable approach is to capitalize on the variation from a variable (the instrument) that is related to whether students take STEM-CTE courses, but unrelated to our outcome of interest except through the

STEM-CTE variable. In other words, we need an instrument that, relative to our outcome of interest, behaves like a random assignment mechanism in an experiment—the mechanism determines treatment status, but its randomness makes it unrelated to any outcome by construction, except through the way it establishes the treatment. STEM-CTE coursetaking is not randomly determined, but the same principle applies in that by using our instrument to predict STEM-CTE coursetaking we capitalize on variation in STEM-CTE coursetaking that is independent of potentially omitted variables, generating a plausibly causal estimate of the relationship between school engagement and STEM-CTE.

Our decision to employ an instrumental variable approach is motivated by two concerns. First, the number of credits a student earns may be a function of the number of STEM-CTE courses a high school offers. This may bias our estimates as schools that offer more STEM-CTE courses likely serve systematically different students than schools that offer fewer courses, and these differences in student populations are related to groups of students that are more or less likely to be engaged. Prior research has demonstrated this connection between school context and course offerings (Iatrola et al., 2011; Monk & Haller, 1993; Sutton, 2017). Second, our estimates may be biased if a student's decision to take a STEM-CTE course is related to their own motivation or ability, which in turn is likely related to school engagement.

We argue that our instrument addresses these concerns. Specifically, our instrument is the residual obtained from a regression using key school characteristics to predict the mean number of STEM-CTE credits completed by student *i*'s peers during junior year at student *i*'s school, not including student *i*'s own STEM-CTE credits. This resulting residual represents the amount of over- or underparticipation in STEM-CTE compared with what we would expect given that school's observable characteristics. This residual-as-instrument approach is an established method for separating predictable versus unpredictable variation in treatment variables (e.g., Hoxby, 2000). Variation in this residual may be attributable to, for example, unobserved differences in school culture around STEM-CTE coursetaking but is unrelated to differential availability of those courses related to observed differences in the population of students the school serves, alleviating the first concern.

Using this school-wide over- or underparticipation in STEM-CTE to predict the number of STEM-CTE credits a student earns relieves the second concern. Here, predicting the coursetaking behavior of one student at a school from the course-taking behavior of the other students at a school is, by construction, free from that student's own motivation and ability (examples of this logic are found in Altonji, 1995; Gottfried & Plasman, 2018b; and Rose & Betts, 2004). Rose and Betts (2004), for example, utilized a version of this instrument such that a student's credits earned in academic subjects was compared with the average number of earned academic credits by that student's peers at the school. Any variation above or below this average could be due to the individual student's ability or motivation. By including this variation in the instrumental variable estimation, we attempt to alleviate bias due to this unobserved ability and motivation thereby helping alleviate the second concern with our baseline model.

Specifically, we created our instrument using the following equation:

$$MEANSTEMCTE_{ij} = \beta_0 + \beta_1 S_j + \Delta_{ij}, \tag{2}$$

where our instrument is the residual Δ_{ij} from the model above using the school-level variables (S_j) identified in Table 1 to predict the mean number of STEM-CTE credits completed by a student's classmates. With this instrument, our estimation occurred in two stages. The first stage was estimated by the following equation:

$$ASCTE_{ij} = \beta_0 + \beta_1 \Delta_{ij} + \beta_2 X_i + \varepsilon_{ij}. \tag{3}$$

$ASCTE_{ij}$ was the predicted number of STEM-CTE credits as estimated by our control variables represented by the vectors X_i for student variables, and our instrument Δ_{ij}, which is the residual as estimated in Equation (2).

In the second stage regression, we used this predicted number of STEM-CTE credits to predict school engagement and STEM-interest. The following equation presents the second-stage model for school engagement:

$$Eng_{ij} = \beta_0 + \beta_1 ASCTE_{ij} + \beta_2 X_{ij} + \beta_3 SchoolVar_j + \varepsilon_i. \tag{4}$$

To date, there is not any single statistical test to unequivocally identify an appropriate instrument. Below, we provide evidence as to the suitability of our chosen instrument.

Table 2 presents some additional tests of robustness for our instrument. First, our instrument is a significant predictor of the observed number of STEM-CTE credits earned in the junior year (0.67, $p < .001$). Additionally, the instrument was significantly predictive of our outcome of interest: junior-year school engagement. However, this predictive relationship disappeared when we included our main independent variable, junior-year STEM-CTE credits, in the estimation. This is exactly the relationship we would hope to see for an effective instrument—related to the outcome of interest, but only through the main independent variable.

Ultimately, instrumental variable estimates should be less biased than those from our baseline model. However, we cannot rule out that there are unobserved factors related both to STEM-CTE coursetaking and engagement. Therefore, we deliberately stop short of claiming our results have a wholly causal interpretation.

TABLE 2

Instrumental Variable Relation to STEM-CTE and Engagement

Instrumental variable	Junior-year STEM-CTE credits, coefficient (*SE*)	Junior-year engagement, coefficient (*SE*)	Junior-year engagement, coefficient (*SE*)
School STEM-CTE credit residual	0.67*** (0.03)	0.17* (0.07)	0.11 (0.07)
Junior-year STEM-CTE credits	—	—	0.07*** (0.02)
F-statistic (first stage)	44.99	—	—
N	19,980	19,980	19,980

Note. Standard errors are in parentheses. STEM = science, technology, engineering, and mathematics; CTE = career and technical education.
*$p < .05$. **$p < .01$. ***$p < .001$.

Results

Engagement

Recall our first research question asked whether STEM-CTE coursetaking links to higher school engagement for STEM-CTE participants. Table 3 presents the baseline ordinary least squares findings from our analyses. The first column presents the results related to our first research question, while the second column provides evidence relevant to our third research question exploring the relationship for low-income students. Finally, the third column presents the relationship for our sample of non-low-income students (i.e., mid-/high-income students). The outcome variable identifies school engagement in junior year. The key predictor is the number of STEM-CTE credits a student completed during junior year.

As seen in the first column of Table 3, STEM-CTE coursetaking is significantly related to engagement (0.08, $p < .001$) for our full student population. In other words, for every additional unit of STEM-CTE an individual earns, school engagement is expected to be 0.08 standard deviations higher than a student who earned no STEM-CTE credits. This equates to an effect size (*ES*) of .03, which, though small, is still significant.

There are a several control variables with significant coefficients worth mentioning. These coefficients help put the magnitude of the relationship between STEM-CTE and engagement in context. First, female students are predicted to have higher school engagement than male students (0.14, $p < .001$). Underrepresented minority students (0.08, $p < .001$) are also predicted to have higher engagement than their counterparts after controlling for all our other variables. As expected, students with higher GPAs early in high school (0.31, $p < .001$; *ES* = .27) and higher engagement in the freshmen year (0.30, $p < .001$; *ES* = .30) are also predicted to be more engaged in the junior year.

At the school level, the only meaningful, significant predictors of school engagement are whether a student attended a public high school and school climate. Students in public high schools (−0.06, $p < .05$) are predicted to have lower engagement than students in nonpublic high schools. School climate is also significantly related to school engagement (0.03, $p < .05$), such that students in schools with perceived better school climate are expected to have higher levels of engagement. Of note, academic units were not related to school engagement, and while other CTE units were related to school engagement, the magnitude was smaller than for STEM-CTE (0.02, $p < .02$; *ES* = .02).

Results by Student Income. The second column in Table 3 presents the baseline estimates for the relationship between STEM-CTE coursetaking and school engagement for our sample of low-income students. Our analysis presented a similar story as that for the full population. As with the full population, our main predictor of STEM-CTE credits earned in junior year remains significant for the low-income population (0.11, $p < .001$; *ES* = .04). The control variables are similarly related in both magnitude and direction. One notable distinction, however, is that low-income students with postsecondary expectations (i.e., those who expected either 2-year or 4-year education) had lower associated school engagement than students with no postsecondary expectations.

The final column in Table 3 presents the results of our analysis for middle- and high-income students to contrast with the low-income sample. Again, STEM-CTE credits is significant (0.06, $p < .01$; *ES* = .02). This finding indicates that STEM-CTE coursework is likely beneficial for students at all income levels, but participation in STEM-CTE may serve as one potential way to close school engagement gaps between low-income and other students.

STEM Interest

Table 4 presents the results in response to Research Questions 2 and 3, which asked whether there was a relationship between STEM-CTE coursetaking and math/science interest. For the sake of parsimony, we only present the coefficients associated with the key independent variables: junior-year STEM-CTE coursetaking and base-year interest measure. Note that the outcome and the baseline measures asked students to respond with respect to the math or science

TABLE 3

STEM-CTE Coursetaking and Engagement

Variable	(1) Full sample, coefficient (*SE*)	(2) Low income, coefficient (SE)	(3) Mid/high income, coefficient (SE)
11th grader STEM-CTE credits	0.08*** (0.02)	0.11*** (0.02)	0.06** (0.02)
Sociodemographic variables			
Female	0.14*** (0.01)	0.17*** (0.02)	0.12*** (0.02)
Underrepresented minority	0.08*** (0.02)	0.08** (0.03)	0.09*** (0.02)
Family arrangement			
Single parent	−0.03 (0.02)	−0.04 (0.02)	−0.02 (0.02)
Other parental arrangement	−0.02 (0.02)	−0.05 (0.03)	−0.01 (0.03)
Highest parent education			
High school diploma or less	0.02 (0.02)	0.04 (0.03)	0.01 (0.03)
Bachelor’s degree or higher	−0.06** (0.02)	−0.06 (0.04)	−0.05* (0.03)
Academic history and attitudes variables			
Academic units through junior year	−0.00 (0.00)	0.00 (0.00)	−0.00 (0.00)
Additional CTE credits	0.02* (0.01)	0.03* (0.01)	0.01 (0.01)
9th- through 10th-grade GPA	0.31*** (0.01)	0.31*** (0.02)	0.31*** (0.02)
Postsecondary expectations			
2 Years or less	−0.07 (0.04)	−0.11* (0.05)	−0.00 (0.06)
4 Years or more	−0.04 (0.03)	−0.08* (0.04)	0.02 (0.04)
Individualized education plan	0.17*** (0.03)	0.18*** (0.04)	0.15*** (0.04)
English language learner	0.16** (0.06)	0.18** (0.07)	0.15 (0.08)
9th-grade engagement	0.30*** (0.01)	0.29*** (0.01)	0.31*** (0.01)
School variables			
Public high school	−0.06* (0.03)	−0.07 (0.04)	−0.07* (0.03)
School climate	0.03* (0.01)	0.03* (0.01)	0.02 (0.01)
Parental involvement	0.02 (0.01)	0.03* (0.01)	−0.01 (0.01)
% English language learners	−0.01 (0.01)	−0.01 (0.02)	0.00 (0.00)
% Free or reduced-price lunch	0.00 (0.00)	−0.00 (0.00)	0.00*** (0.00)
% Underrepresented minorities	−0.00 (0.00)	0.00 (0.00)	−0.00 (0.00)
N	19,980	8,380	11,590

Note. Standard errors are in parentheses. STEM = science, technology, engineering, and mathematics; CTE = career and technical education.
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

course in which they were enrolled at the time. The sample sizes, therefore, are smaller than those for our engagement estimates since there were a number of students who were not enrolled in a math or science course at the time of the survey.

Our baseline estimates indicate that there is a significant relationship between STEM-CTE coursetaking and math interest (0.04, $p < .01$). While the full population exhibits a significant relationship, this is not the case when breaking apart the population by income level. Within the mid-/high-income sample, there is a significant relationship such that STEM-CTE participation relates to higher math interest (0.05, $p < .05$); however, there is no significant relationship low-income students. Across each model, prior math interest was a significant predictor of later math interest. STEM-CTE was not a significant predictor of science interest in 11th grade across any of our models, though 9th-grade science interest was a strong predictor of later science interest.

Instrumental Variable Results

To account for potential unobserved variable biases, we reestimated our models using the instrumental variable estimation technique described above. Table 5 presents the results of the instrumental variable estimations. We only present the coefficients of interest for the sake of parsimony, though we do include all control variables.

We observe a significant relationship between STEM-CTE and school engagement in our full population (0.23, $p < .05$; *ES* = .08) and for our population of low-income students (0.26, $p < .05$; *ES* = .10). There is not a significant relationship for middle- and high-income students (though

TABLE 4
STEM Interest

Interest	(1) Full sample, coefficient (*SE*)	(2) Low income, coefficient (*SE*)	(3) Mid/high income, coefficient (*SE*)
Math interest			
11th-grade STEM-CTE credits	0.04* (0.02)	0.03 (0.03)	0.05* (0.03)
9th-grade math interest	0.34*** (0.01)	0.34*** (0.01)	0.34*** (0.01)
N	13,550	5,170	8,390
	(4) Full sample, coefficient (*SE*)	(5) Low income, coefficient (*SE*)	(6) Mid/high income, coefficient (*SE*)
Science interest			
11th-grade STEM-CTE credits	−0.01 (0.02)	0.03 (0.03)	−0.03 (0.03)
9th-grade science interest	0.24*** (0.01)	0.23*** (0.02)	0.25*** (0.01)
N	11,570	4,210	7,360

Note. A number of students were not enrolled in a math or science course during their junior year were therefore excluded from the analyses. Standard errors are in parentheses. STEM = science, technology, engineering, and mathematics; CTE = career and technical education.

the magnitude is similar to that for the low-income population). Particularly for low-income students, our more robust estimates obtained through the instrumental variable models indicate that STEM-CTE coursework can play role in promoting school engagement. While the *ES* of .10 may be relatively small, this should be considered a substantial effect in education research (Kraft, 2020).

Though we continue to observe a significant relationship between STEM-CTE and school engagement under our instrumental variable estimates, the same cannot be said for math and science interest. Under our baseline estimates of math interest, recall that we did observe a significant relationship for the full population and the middle- and high-income student sample. Our more robust instrumental variable estimates indicate that there is no significant relationship between STEM-CTE coursetaking and either math or science interest for low-income students.

Discussion

Low levels of school engagement have many negative academic consequences for students, the burden of which falls disproportionately on low-income students. Using a multidimensional measure of school engagement that captures behaviors ranging from attendance to preparation for class, we find that low-income students who take STEM-CTE courses in their junior year of high school are more engaged in school compared their non-STEM-CTE counterparts. Although we do not directly observe the mechanism by which STEM-CTE coursework links to higher engagement, it may be due to the applied nature of these courses making the traditionally theoretical and technical work in STEM fields more interesting for students, encouraging them to be present, physically and mentally.

Our work builds on prior work in two important ways. First, we explore the relationship between STEM-CTE coursework and school engagement specifically for a population of students at risk for disengagement—that is, low-income students. Second, we improved on an instrument used in previous STEM coursetaking work (Altonji, 1995; Gottfried & Plasman, 2018b; Plasman & Gottfried, 2020; Rose & Betts, 2004), providing evidence of the relationship between STEM-CTE coursetaking and school engagement that likely has less omitted-variable bias from confounding student- and school-level factors. Although future work should confirm these differences with different data, our results suggest potentially important benefits and limitations of the extent to which STEM-CTE can benefit low-income students.

Our results are in line with a growing body of research that find evidence that career-oriented schoolwork—whether through well-defined career pathways, comprehensive career academies, or CTE coursework—affects the way students engage with school in beneficial ways (Bonilla, 2020; Fletcher et al., 2020; Hemelt et al. 2019). For example, Bonilla (2020) argues increased student motivation is part of the reason she observed lower dropout rates among students who had access to career pathways. Similarly, Fletcher et al. (2020) found that students in career academies were more likely than students in traditional schools to be emotionally engaged with school.

TABLE 5

Instrumental Variable Estimation Results

	(1)	(2)	(3)
Instrumental variable	Full sample, coefficient (*SE*)	Low income, coefficient (*SE*)	Mid/high income, coefficient (*SE*)
Behavioral engagement			
Junior-year STEM-CTE credits	0.23* (0.09)	0.26* (0.13)	0.21 (0.12)
9th-grade behavioral engagement	0.30*** (0.01)	0.29*** (0.01)	0.31*** (0.01)
Kleibergen–Park Wald *F* statistic	417.95	191.80	225.73
N	19,980	8,380	11,590
	(4)	(5)	(6)
	Full sample, coefficient (*SE*)	Low income, coefficient (*SE*)	Mid/high income, coefficient (*SE*)
Math interest			
Junior-year STEM-CTE credits	−0.10 (0.12)	−0.07 (0.16)	−0.12 (0.15)
9th-grade math interest	0.34*** (0.01)	0.34*** (0.01)	0.34*** (0.01)
Kleibergen–Paap rk Wald *F* statistic	276.26	124.77	148.77
N	13,550	5,170	8,390
	(7)	(8)	(9)
	Full sample, coefficient (*SE*)	Low income, coefficient (*SE*)	Mid/high income, coefficient (*SE*)
Science interest			
Junior-year STEM-CTE credits	−0.23 (0.15)	0.02 (0.19)	−0.43* (0.19)
9th-grade science interest	0.24*** (0.01)	0.23*** (0.02)	0.25*** (0.01)
Kleibergen–Paap rk Wald *F* statistic	281.00	118.73	161.59
N	11,570	4,210	7,360

Note. Standard errors are in parentheses. STEM = science, technology, engineering, and mathematics; CTE = career and technical education.
$*p < .05$. $**p < .01$. $***p < .001$.

Our findings, together with these earlier results and other evidence demonstrating the value of CTE coursework on student attendance, demonstrates an increasingly clear picture of career-oriented coursework offering something that traditional coursework does not in helping motivate students to be more engaged and present in their schoolwork. Because one of the main differences between STEM-CTE and traditional STEM coursework is the emphasis on applied and practical content, it may be worth considering how traditional STEM courses could work to make the practical elements of the work more transparent because of the school engagement benefits that may come from it.

The link we show between STEM-CTE coursetaking and higher school engagement helps solidify one theorized mechanism for other observed benefits of STEM-CTE coursetaking. However, the finding that math and science interest is not linked to STEM-CTE coursetaking for these low-income students implies that it may be worth investigating links to these different academic STEM-related fields separately. Considering the strong relationship between early math/science interest and later math/science interest, it may be the case that taking just a course or two in STEM-CTE is not enough to overcome these baseline attitudes.

The STEM-CTE link to higher school engagement for low-income students is particularly compelling given the challenges low-income students face with matters of school engagement—like attendance—and that the counterfactual group includes *all* other low-income students, including those who took traditional STEM courses as well students who, rather than taking a STEM-CTE course, did not take a STEM course at all. In other words, low-income students who took STEM-CTE coursework had higher school engagement than both students who we might expect to have low school engagement—that is, those who appear disengaged from the STEM curriculum and are not enrolled in any STEM course—and those who we would expect better engagement from—students who are in traditional high school coursework.

Given links between school engagement factors like absenteeism and school climate (Van Eck et al., 2017), it may also be that there are cumulative benefits to the school engagement boosts that are associated with higher rates of STEM-CTE coursetaking: higher rates of school engagement may be associated with broad improvements in overall school climate.

Despite our promising results, more work is needed to understand other benefits low-income students might receive from Perkins-sponsored courses, not only to understand the value of Perkins' funding but also its limits and where additional supports can help the academic success of low-income students. Work like that of Bonilla (2020) who studies the effect of targeted state funding to supplement other sources of CTE support is particularly valuable given how state funding makes up a large proportion of CTE support.

Alongside work to understand how to better fund and support CTE programs should be work that explores how to increase CTE participation, particularly among populations like low-income students. Although STEM-CTE participation has been increasing over time (Plasman et al., 2020), the average number of junior-year STEM-CTE credits earned by low-income students in our sample was only one tenth of a credit. If a goal of Perkins legislation is to increase participation by "special populations" of students, it may be necessary to explore options to reach these populations and encourage their participation in STEM-CTE specifically. These efforts may be particularly effective if targeted to later high school years given our finding here that junior-year AS-CTE coursetaking was associated with higher levels of school engagement and other research showing CTE courses taken later in the high school years may be more beneficial (Gottfried & Plasman, 2018b).

Limitations

There are a few limitations to our work worth mentioning. First, there is no explicit measure of school engagement, a "soft" skill, like test scores or annual improvement. While there is research that validates the use of behavioral scales and softer skills (e.g., Koppenhaver, 2006; Sticcal et al., 2017), we cannot know for certain whether we are measuring authentic school engagement. Additionally, although we use a measure of ninth-grade engagement to capture an estimate of a student's baseline school engagement, this measure was collected very near the beginning of the school year, which may not have captured a student's true high school behavior due to adjusting to new expectations and the high school environment. However, engagement tends to decrease throughout high school (Brenneman, 2016), so it is likely this early measure of engagement overstated a student's baseline engagement, attenuating our estimates of engagement changes by junior year.

An additional limitation is that we do not have access to information regarding the curricular and instructional aspects of these STEM-CTE courses. Future studies could take a more qualitative look at how STEM-CTE courses are more engaging and how students view them as such. This could help provide a more robust understanding of the link between STEM-CTE and engagement and the myriad of outcomes related to school engagement (e.g., attendance, dropout) and how the quality of such courses may play a role.

Finally, because our analyses were not based on experimental data, our results should not be interpreted as truly causal. We attempted to mitigate this issue through our quasi-experimental modeling techniques. However, we cannot rule out potential remaining factors that may affect both coursetaking choices and school engagement. Future research may be able to implement a randomized controlled experiment by which students are randomly assigned to participate in STEM-CTE coursework. Such a study could further expand the understanding of the connection between STEM-CTE and a variety of student outcomes, including school engagement.

Conclusion

Despite these limitations, the results of our study are quite encouraging. The potential for STEM-CTE to encourage school engagement is an important finding related to high school as well as to college and career success (Stone & Lewis, 2012). Our study was the first to explore how STEM-CTE relates to school engagement and STEM interest for low-income students. These findings provide a potential pathway for schools as they explore different means to improve school engagement. Finally, our study provides evidence that funding for career and technical education through the Perkins Act can help produce promising outcomes for disadvantaged students.

As the nation looks to find additional ways to encourage STEM interest and celebrate nonacademic successes, CTE may provide a unique opportunity to emphasize some of these alternative aspects of success. In the summer of 2018, the Perkins Act was once again reauthorized. This reauthorization, which went into effect at the beginning of the 2019–2020 school year, has continued to focus on integrating academic learning with applied learning. Additionally, it has expanded the accountability indicators around academic performance to include science. These changes highlight a commitment by the federal government to promote STEM learning through less traditional means and hold promise for students to access the many benefits of these courses.

Appendix

Created variables	HSLS variable names
Junior-year STEM-CTE credits	T3SCRED, T3SSCED, T3SGRLEV, X3TCREDENGIN, X3TCREDCOMPSCI
11th-grade engagement	X2BEHAVEIN
Math interest	X1MTHINT, X2MTHINT
Science interest	X1SCIINT, X2SCIINT
Sociodemographic variables	
Female	X1SEX
Underrepresented minority	X1RACE
Family arrangement	
Single parent	X1P1RELATION, X1P2RELATION
Both biological parents	
Other parental arrangement	
Highest parent education	
High school diploma or less	X2PAR1EDU, X2PAR2EDU
Some college	
Bachelor's degree or higher	
Academic history and attitudes variables	
Academic units earned through junior year	T3SCRED, T3SSCED, T3SGRLEV, X3TCREDACAD
9th- through 10th-grade GPA	X3TGPA9TH, X3TGPA10TH
Postsecondary expectations	
No college	S1EDUEXPECT
2 years or less	
4 years or more	
Individualized education plan	X1IEPFLAG
English language learner	X3ELLSTATUS
School engagement	X1SCHOOLENG
Additional CTE credits	T3SCRED, T3SSCED, T3SGRLEV, X3TCREDENGIN, X3TCREDCOMPSCI, X3TCREDCTE
School variables	
Public high school	X1CONTROL
School climate	X1SCHOOLCLI
Parental involvement	A1PRNTINV
Percentage of ELL	A1ELL
Percentage of FRL	A1FREELUNCH
Percentage of underrepresented minorities	A1HISPSTU+A1BLACKSTU+A1AMINDIANST

Note. STEM = science, technology, engineering, and mathematics; CTE = career and technical education; ELL = English language learner; FRL = free or reduced-price lunch.

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