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Linking the Timing of Career and Technical Education Coursetaking With High School Dropout and College-Going Behavior

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While prior studies have examined the efficacy of career and technical education (CTE) courses on high school students' outcomes, there is little knowledge on timing of these courses and a potential link to student outcomes. We asked if the timing of these courses predicted differences in the likelihood of dropout and on-time high school graduation as well as college-going behaviors. We found that CTE coursetaking in high school was linked to lower chances of dropout and increased chances of on-time graduation, especially when these courses were taken later in high school. Little evidence arose that CTE coursetaking boosts college-going behaviors. The implications speak to the role of timing of CTE coursetaking, specifically on end of high school outcomes.

KEYWORDS: career and technical education, high school, dropout, high school completion, college-going

In the early 1940s, 60% of the American population between the ages of 25 and 29 had not completed a high school degree (Rumberger, 1987). Since that time, there have been numerous innovations and developments addressing dropout prevention—ranging from school-community

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collaboration to alternative schooling (Schargel & Smink, 2001). Despite these efforts, the absolute number of students who are considered dropouts remains extremely high. While the annual high school dropout rate (measured as the percentage of students who do not graduate and do not return to school the following year) has slowly decreased over the past decade to a rate of 3.3% in 2011, there are still 3 million young people between the ages of 16 and 24 who are not enrolled in high school and do not have any high school credential (Kaufman, Alt, & Chapman, 2004; U.S. Census Bureau, 2012).

Attaining a high school credential is linked to many individual-level benefits, including greater likelihood of attending college and improved employment opportunities (Schargel & Smink, 2001). In addition to these individual benefits, there are certainly spillover effects. Individual academic and employment gains from high school completion successfully contribute to the welfare of a community through lower unemployment, increased payment of taxes, and reduced reliance on social programs that are associated with education (Plank, DeLuca, & Estacion, 2008; Schargel & Smink, 2001). Additionally, those who complete high school tend to have stronger health and lower mortality rates as well as a lower likelihood of committing crimes (Rumberger, 2010). Considering these broad-reaching benefits, our nation's communities in general stand to gain a great deal from increased numbers of students attaining high school credentials.

As national leaders have experimented with various policies aimed at reducing the prevalence of dropout, career-related education has been a consistent focus as a means for students to remain on the school-to-career pathway. The federal government took a direct interest in career-linked schooling in the early 20th century and implemented the Smith-Hughes Act of 1917 to fund training of vocational education teachers and vocational education programs. Current career and technical educational policy and practice—now based on the Carl D. Perkins Career and Technical Education Act (currently in its fourth iteration: Perkins IV)—began as the Vocational Education Act of 1963, which firmly entrenched vocational education as a fixture in high schools. During the past decade, vocational education has been rebranded and expanded to incorporate a broader range of career and technical education (CTE) courses. The Perkins Act has represented a concerted effort by the federal government to continue to foster the connection between high school content and college-going as well as career opportunities (American Insititutes for Research, 2013). Perkins IV placed an emphasis on aligning hands-on, job-related skills with academically challenging coursework in high school. Through the Perkins Act, CTE courses were designed 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). Essentially, the goal of the act was to align applicable career-related skills with academically challenging coursework in high school.

The association between vocational education (as it was originally called) and dropout prevention has long been discussed (Plank et al., 2008). Reviews of successful dropout prevention programs have noted the emphasis placed on these CTE courses as a focus for these programs (Rumberger, 1987). Subsequent research has backed up the assertions that CTE does have the potential to reduce the odds of dropout and increase the odds of high school completion (Wonacott, 2002). These studies have examined the ability of CTE courses to engage students more thoroughly in school and create a more tangible connection between schoolwork and postsecondary experiences, be that in college or career (Stone & Alfeld, 2004). A study using NLSY:97 data by Plank et al. (2008) also examined the connection between enrollment in CTE coursework and high school dropout. They found that a balance of approximately one CTE course to two academic courses was the point at which students entering high school at younger than 15 years old benefited the most from CTE. These patterns held across international comparisons as well: Increased numbers of students involved in CTE (or vocational education) across the sample of countries was associated with increased high school graduation rates (Bishop & Mane, 2004).

While there has been a good amount of research into this connection between high school completion and CTE, there are several key issues that previous research has not addressed. First, there has been little research regarding college-going behaviors for students taking CTE courses. This void is glaring given that CTE coursework does aim to forge connections for students about college and career opportunities beyond high school completion. The research that exists has focused only on whether a student ever attended a college (Arum & Shavit, 1995; DeLuca, Plank, & Estacion, 2006). Arum and Shavit (1995) concluded that enrollment in a vocational track in high school was related to slightly decreased odds of enrollment in postsecondary education (PSE) for certain populations of students. DeLuca et al. (2006) also found increased levels of CTE participation in high school to be related to lower chances of PSE participation. However, neither of these studies focused specifically on the further details in regards to PSE (e.g., immediate enrollment after high school, enrollment within two years of high school, or ever enrolled at a postsecondary institution). Postsecondary enrollment is becoming a practical necessity as more and more jobs require increased technical skills and expertise than was required in previous generations (Brand, Valent, & Browning, 2013). As a key push behind current CTE policy is to help prepare students to be college and career ready, it is important to test whether this is the case, as we do here.

Second, a majority of the studies mentioned previously examined the propensity for a student to drop out of high school. However, few studies have directly explored the association between CTE and successful completion of high school within four years (i.e., on time). This is a key oversight. Students completing high school on time are more likely to receive a postsecondary degree, earn a higher income, and exhibit healthy life behaviors (Hull, 2009). Additionally, students who drop out for even a portion of time—thereby not graduating on time—are at a greater risk of neither working nor pursuing postsecondary opportunities compared to those who do graduate on time (Measure of America/Opportunity Nation, 2014). Therefore, helping to promote on-time graduation could be an important yet understudied benefit of CTE. Furthermore, four-year cohort high school graduation rates have become an important indicator to measure school success for numerous states across the country, including California, which educates over an eighth of all the students in the country (California Department of Education, 2017). Understanding the role CTE may play in improving this four-year cohort graduation rate would be a key contribution from this study. Finally, and perhaps most intriguing for our current study, no previous research has looked at the effect of when these CTE courses were taken (early or late in high school) and its link to high school completion and dropout.

The Role of CTE

Based on previous work by Gottfried, Bozick, Rose, and Moore (2016); Gottfried (2015); and Plank et al. (2008), we speculate three mechanisms by which CTE courses may affect high school completion/dropout and college-going generally speaking (without yet considering the role of timing). The first is skill building. CTE courses stress the development of critical thinking, reasoning, logic, collaboration, research and development, and problem solving (American Insititutes for Research, 2013; Schargel & Smink, 2001). The intention of these courses is that students may gain a broader range of skills as they develop knowledge from within CTE courses and then apply it elsewhere in high school (Gottfried et al., 2016), thereby boosting all-around school success (American Insititutes for Research, 2013). Extending beyond high school, CTE courses in high school were also designed to build skills such that students are college-ready, especially for certain two-year or certificate programs, upon graduation from high school (American Insititutes for Research, 2013; Oakes & Saunders, 2008; Stern & Stearns, 2006).

The second mechanism is engagement. CTE courses are stressed as being more educationally engaging compared to traditional courses, which can be abstract or theoretical (Bozick & Dalton, 2013; Gottfried et al., 2016). As CTE courses focus on the link between traditional content and its career-based applications, school material has the potential to become more engaging through hands-on experiences and applied contextual learning (American Insititutes for Research, 2013). As such, CTE coursetaking is designed to boost engagement, and students more engaged in high school tend to have decreased dropout rates (Kemple & Snipes, 2000). Therefore, a higher probability of graduation may follow, particularly given the underlying theory of action linking CTE in high school to both college and career opportunities (Partnership for 21st Century Skills, 2010).

The final mechanism is real-world relevance. Because CTE courses are designed to lie in the nexus between traditional content and applied, practical relevance (American Insititutes for Research, 2013), taking CTE courses has the potential for students to develop an understanding of the importance of high school content as it links to opportunities immediately afterward (Stone & Lewis, 2012), including both postsecondary education as well as long-term career opportunities. Proponents and instructors of CTE also believe a major strength of these occupational programs is in their ability to promote career readiness skills (Partnership for 21st Century Skills, 2010).

Each of these mechanisms is closely related to previous theories explaining educational engagement and academic pursuits. Skill building connects closely with the frustration–self-esteem model proposed by Finn (1989). Under this model, CTE courses help enhance key skills that help students succeed in many areas, thereby increasing overall academic self-esteem. Additionally, CTE courses are related to educational persistence through life course models as students with improved skills will likely have improved positive associations with school both in high school and beyond (Alexander, Entwisle, & Kabbini, 2001; Ensminger & Slusarcick, 1992). The second and third mechanism are connected to dropout via a model proposed by Wehlage, Rutter, Smith, Lesko, and Fernandez (1989). CTE courses help make school work more practical, which helps connect students with school through improved educational engagement. The third mechanism of real-world relevance as promoted by CTE helps to encourage school membership, thereby further enhancing engagement. Engagement is a common thread running through many of the theories explaining dropout, and high school completion is often used as an indicator of student engagement (California Department of Education, 2017). Hence, while the mechanisms described previously are theoretical, they do have roots in literature that suggests that CTE might influence both high school completion as well as further educational persistence.

The Role of Timing

Examining the timing of these CTE courses is an important factor to take into consideration as students might benefit differently based on when they took CTE courses. Though no prior research study has examined when courses were taken, we believe that each of the aforementioned mechanisms might relate uniquely to early or late high school coursetaking. Early in a student's high school career (9th and 10th grades), taking CTE courses might provide scaffolding for future learning potentially through the first and second mechanisms. First, academic skills learned (in addition to "soft" skills such as learning how to behave as a high school student) can be more broadly applied to other types of courses outside of the CTE taxonomy, and the accumulation of skills early on may work to promote educational attainment (Heckman & Rubinstein, 2001). As described by Schargel and Smink (2001), the skills learned in CTE courses are certainly transferable to other core academic subjects, hence further promoting skill building across domains. As for engagement, in addition to early exposure providing academic scaffolding through skill building, CTE courses might also increase early interest and engagement in school work (Reiser, 2004). Students at risk of dropout tend to become disengaged with school either due to lack of competence in courses or a belief that coursework is not meaningful (Marks, 2000). Providing meaningful work from the start of high school via CTE coursework might help to curb this disengagement.

In later years of high school, the rate of dropout becomes greater (Snyder & Dillow, 2015; U.S. Department of Education, 2012). For instance, according to the U.S. Department of Education (2012), the rate of dropout in 12th grade was approximately double the rate in 9th grade. Hence, in later years, CTE can act as a safety net for those students most in danger of leaving school without a high school credential. In addition to skill building and engagement in course material that early CTE coursetakers might experience, those who take CTE courses later might also experience a greater sense of relevance—namely, the third mechanism. As described by Gottfried et al. (2016), Bozick and Dalton (2013), and Stone and Lewis (2012), CTE courses were designed specifically to bring into focus the connection between school and career. There is the potential, then, to increase the urgency of completing school and continuing on to postsecondary opportunities. This connection could become even more important as students approach the end of their high school careers and begin to see immediate payoffs to educational attainment. Understanding how timing may affect the various outcomes can help to identify how the three mechanisms relate across a high school career as well as why it might be important to encourage enrollment in CTE at different points in high school.

This Study

Given the potential for both early and late CTE coursetaking to be linked differentially to high school completion and given the lack of research on other key outcomes, we asked the following research questions in reference to a nationally representative cohort of students who were observed in high school starting their second semester of their sophomore year:

Research Question 1: Does taking CTE courses in high school predict differences in high school dropout and on-time graduation?

Research Question 2: Does the timing of when these CTE courses were taken predict differences in high school dropout and on-time graduation?

Research Question 3: Beyond these outcomes, does the timing of when these CTE courses were taken predict differences in college-going behaviors?

The first research question examines the role of CTE coursetaking in general on high school dropout. Knowing if there is any effect of CTE coursetaking across a student's high school career has important implications for understanding what factors contribute to school persistence. Through the second research question, we make a promising contribution to the CTE/high school dropout literature through an understanding of whether timing is important in increasing this high school persistence. Our final question also helps to gain a broader understanding regarding the influences CTE coursetaking and its timing may have on high school students beyond high school. Gaining an understanding of when students benefit the most from CTE coursetaking will allow for education policies to be more fully developed to address students' needs from high school to the transition to college.

To answer these questions, we utilized the Educational Longitudinal Study of 2002 (ELS:2002)—a large-scale national data set with student-level observations that were linked to high school transcript data collected by the U.S. Department of Education. In addition to high school coursetaking, the data set included information on individual demographics, school performance, and attitudes. In order to reduce bias in the link between CTE coursetaking and our set of outcomes, we included a rich set of control variables as well as use of an instrumental variable strategy grounded in prior research addressing the role of high school coursetaking on student outcomes (Altonji, 1995; Brooks, Chavez, Tritz, & Teasley, 2015). The use of these methods allowed us to come to meaningful conclusions regarding CTE coursetaking and high school outcomes as well as college-going behaviors. It is important to note that the ELS data set began following students during the second half of the sophomore year in high school. Therefore, any conclusions regarding the timing of CTE in relation to high school completion are limited to those students who successfully progressed through high school up to that point.

Method

Data Set Overview

The ELS:2002 data set was compiled by the National Center for Education Statistics (NCES) at the U.S. Department of Education. ELS:2002 followed a cohort of students enrolled in the 10th grade in 2002 and continued tracking these students as they completed high school and transitioned into college and/or employment. Spring 2002 was the base year for the study, at which point students, teachers, parents, and administrators were all asked to complete questionnaires. Students were reinterviewed in spring 2004 (first follow-up) when a majority of participants were in their senior year and again in the spring of 2006 (second follow-up) when participants would have been in their second year after high school graduation.

A key piece to a study on coursetaking patterns was the aggregation of high school transcripts by NCES. Transcript data were collected in 2005 when most of the students had completed high school, and high school degree verification was completed. In this present study, transcript data were merged with other survey data collected across the base year and the two follow-up waves. The data included full coursetaking histories for students in the study, along with the grades and credits they earned. These coursetaking files were included for 91% of the students who participated in the baseline sample in 2002. The credits were standardized to Carnegie units to ensure a common measurement across schools. A single Carnegie unit is recognized as a course taken for one period every day throughout a school year.

We conducted several checks to assure transcript files were accurate. First, discrepancies between credits and course grades were resolved to ensure credit was only given for passed courses. Second, any duplicate course records were removed. Finally, credit assignment was reviewed to ensure compatibility with the school's calendar system (e.g., semester, block, etc.). After these checks were complete, the course data represented an accurate indication of the total number of credits earned by each student for completion of a given course in a given year of high school.

The final cleaned and coded data provided an overall picture for each participant in the ELS:2002 sample for this study. For all our analyses, we chose to focus on public school students because attending private schooling might have been serving as a proxy for some of the unobserved variables that we might be most concerned about. Public schools are also supported as presenting a more uniform sample of students based on social, cultural, and economic factors (Wang, 2015). Finally, public schools serve to educate a majority of the children in the United States, and policy focuses on these schools.

Therefore, inclusion in this sample relied on valid transcript information and nonmissing outcomes for all public school students. To deal with missing values, mean value imputation with missing value dummy indicators was employed, as consistent with previous research (Donner, 1982; Fletcher, 2010; Raymond & Roberts, 1987). This resulted in approximately N = 11,000 student observations. Per NCES rules, all sample sizes of four digits have been rounded to the nearest 10. Note that the ELS:2002 data set includes probability weights to ensure estimates based on subsamples are appropriately representative of all students in the United States.

Outcomes

There were a number of key outcomes examined in this study. These measures were broken into two categories: high school outcomes and college-going behaviors. Regarding high school outcomes, dropout and on-time graduation were examined. First, dropout was sourced from the second follow-up survey, at which point it was possible to determine if students had successfully completed high school or not. Included was a binary variable indicating whether or not a student dropped out of high school and did not return prior to receiving a credential. It is important to note that successful completion of high school under this definition did not include receiving a GED, only those who received a traditional high school diploma. This was chosen as the dropout definition due to distinct and important differences as well as eventual outcomes—both in the long term and short term—between students receiving a high school diploma and those receiving a GED (Murnane, Willett, & Tyler, 2000). Additionally, considering ELS began surveying students in the second semester of their sophomore year, this dropout indicator was not able to identify students who dropped out prior to this period and never returned to school. Therefore, a definition of dropout in this context is based on those students who were in high school in the second semester of their 10th-grade year (i.e., the time at which these data were collected) but had left at some point thereafter and never returned.

A second important end of high school outcome, on-time graduation, was also derived from the second follow-up survey, which identified when students received their high school diploma. We identified this as a binary variable indicating whether a student received a high school diploma by the expected graduation date within four years of beginning high school. This was possible to compute using the ELS variable identifying student start date in combination with the variable identifying when a student received a high school diploma.

The following college-going behaviors were recorded in the data set: ever applied to PSE (1 = ever applied, 0 = never applied), enrolled in PSE immediately after high school (1 = enrolled immediately, 0 = did not enroll immediately), enrollment in PSE within two years of high school completion (1 = enrolled during second follow-up, 0 = not enrolled during second follow-up), and enrolled in PSE at any point (1 = ever enrolled, 0 = never enrolled). Enrolled in PSE immediately after high school was a binary indicator taken from the first follow-up survey. The final three variables (ever applied, ever attempted, and enrolled within two years) were taken from the second follow-up and were set up as binary indicators.

CTE Units Completion

Based on the secondary school taxonomy published by NCES (Bradby & Hudson, 2007), it was possible to organize students' transcripts into four specific areas: academic, career and technical education, enrichment/other, and special education. This study focuses on those courses from the CTE category. In this broad range of CTE courses, there were 21 identified occupational course categories included in the NCES data set that were based on the actual 21 categories identified by Bradby and Hudson (2007) in their report on secondary school course taxonomy. These categories include the following: agriculture and natural resources, communications and design, computer and information sciences, health sciences, marketing, business support, business management, business finance, engineering technologies, architecture, construction, manufacturing, mechanics and repair, transportation, consumer services, culinary arts, education, library science, public administration, legal services, and protective services (Bradby & Hudson, 2007).

We looked first at CTE coursetaking (herein referred to as number of units of CTE completed) aggregately taken across all high school in Grades 9 through 12. Subsequently, we examined CTE coursetaking specifically in each grade individually. We separately examined these periods because of the possibility for timing to impact the relevance of CTE (i.e., early high school CTE coursetaking in 9th or 10th grade may be linked to providing scaffolding for students to build on throughout high school, and during the later high school years of 11th and 12th grade, the importance of these CTE classes might move from scaffolding development to focus more on relevance to post–high school opportunities).

Throughout this study and for all time periods, CTE coursetaking was the number of units a student had taken. We chose to use CTE units in an attempt to observe the role of CTE coursetaking in a more standardized way. Both across schools and within schools, it is possible that students completed different numbers of academic units, and therefore an analysis of the CTE to academic unit ratio would be directly biased by these differences. With the understanding that academic units play a key role in the path to high school completion, we did include academic units as a control variable as described in the following section. Note that we also examined the potential for a nonlinear relationship between CTE unit completion and our outcomes through inclusion of a quadratic term, as had been done in previous research (Plank et al., 2008), but found that this term was not significant and did not improve model fit in any of our estimations. An explanation for this difference may be due to the fact that previous research used a CTE to academic unit ratio as the main predictor while we used CTE units as mentioned previously.

Control Variables

Table 1 presents descriptive statistics for the variables included in the study. Those selected were grounded in previous research in high school completion and CTE (Adelman, 2006; Bozick & Dalton, 2013; Brody &

Table 1
Mean Values for All Included Covariates Broken Down by Quartile

	Full Sample	First Quartile: 0 to 1.25 CTE Units	Second Quartile: 1.25 to 2.5 CTE Units	Third Quartile: 2.5 to 4.5 CTE Units	Fourth Quartile: More Than 4.5 CTE Units
9th-grade CTE units	0.69 (1.03)				
10th-grade CTE units	0.78 (1.14)				
11th-grade CTE units	1.00 (1.29)				
12th-grade CTE units	1.23 (1.47)				
Student level					
Demographic data					
Gender (female)	0.50 (0.49)	0.56 (0.48)	0.52 (0.49)	0.50 (0.49)	0.46 (0.49)
Race/ethnicity					
Black	0.13 (0.33)	0.08 (0.26)	0.11 (0.31)	0.14 (0.34)	0.14 (0.34)
Hispanic	0.15 (0.34)	0.13 (0.32)	0.15 (0.35)	0.14 (0.34)	0.12 (0.32)
Asian	0.10 (0.29)	0.12 (0.32)	0.12 (0.32)	0.09 (0.28)	0.05 (0.21)
White	0.57 (0.50)	0.62 (0.49)	0.56 (0.50)	0.57 (0.50)	0.64 (0.48)
Family data					
Family arrangement					
Single-parent household	0.22 (0.41)	0.18 (0.37)	0.20 (0.39)	0.23 (0.41)	0.24 (0.42)
Both biological parents	0.59 (0.49)	0.70 (0.46)	0.66 (0.47)	0.58 (0.49)	0.55 (0.50)
Other arrangement	0.16 (0.36)	0.12 (0.31)	0.14 (0.33)	0.17 (0.37)	0.19 (0.39)
Highest parental education					
High school or less	0.26 (0.43)	0.14 (0.34)	0.21 (0.39)	0.28 (0.44)	0.36 (0.47)
Some college	0.33 (0.47)	0.25 (0.43)	0.34 (0.47)	0.35 (0.48)	0.39 (0.49)
BA degree or more	0.41 (0.48)	0.60 (0.48)	0.46 (0.49)	0.38 (0.47)	0.25 (0.43)

(continued)

Table 1 **(continued)**

	Full Sample	First Quartile: 0 to 1.25 CTE Units	Second Quartile: 1.25 to 2.5 CTE Units	Third Quartile: 2.5 to 4.5 CTE Units	Fourth Quartile: More Than 4.5 CTE Units
Family income					
Lowest 25%	0.21 (0.41)	0.12 (0.32)	0.17 (0.38)	0.22 (0.41)	0.26 (0.44)
Between 25% and 75%	0.51 (0.50)	0.44 (0.49)	0.51 (0.50)	0.54 (0.50)	0.58 (0.49)
Highest 75%	0.28 (0.45)	0.44 (0.50)	0.32 (0.47)	0.24 (0.43)	0.16 (0.37)
Academic history and attitudes					
9th-grade GPA	2.60 (0.85)	2.98 (0.80)	2.75 (0.85)	2.60 (0.86)	2.40 (0.81)
Academic units	22.38 (4.30)	24.41 (4.16)	23.50 (4.13)	22.00 (3.89)	20.08 (3.77)
Importance of education	0.89 (0.30)	0.91 (0.28)	0.90 (0.30)	0.89 (0.30)	0.86 (0.34)
Math self-efficacy	2.61 (0.62)	2.71 (0.70)	2.62 (0.67)	2.58 (0.66)	2.52 (0.65)
Parent involvement schooling	2.18 (0.46)	2.26 (0.48)	2.21 (0.49)	2.18 (0.48)	2.10 (0.49)
Employed outside the house	0.34 (0.43)	0.37 (0.47)	0.35 (0.46)	0.34 (0.45)	0.28 (0.43)
Involved in extracurricular activities	1.50 (1.27)	1.82 (1.31)	1.63 (1.34)	1.46 (1.33)	1.22 (1.28)
Postsecondary expectations					
Any college	0.14 (0.33)	0.06 (0.22)	0.10 (0.29)	0.15 (0.35)	0.25 (0.43)
Complete four-year degree or more	0.72 (0.43)	0.87 (0.32)	0.80 (0.39)	0.72 (0.43)	0.55 (0.49)
School level					
Region/urbanicity					
Northeast	0.18 (0.39)	0.22 (0.41)	0.18 (0.39)	0.16 (0.37)	0.14 (0.35)
West	0.20 (0.40)	0.25 (0.43)	0.25 (0.44)	0.20 (0.40)	0.11 (0.32)
Midwest	0.25 (0.43)	0.21 (0.41)	0.24 (0.43)	0.28 (0.45)	0.30 (0.46)
South	0.36 (0.48)	0.32 (0.47)	0.32 (0.47)	0.36 (0.48)	0.45 (0.50)
Urban	0.34 (0.47)	0.44 (0.50)	0.36 (0.48)	0.28 (0.45)	0.19 (0.40)
Suburban	0.48 (0.50)	0.46 (0.50)	0.50 (0.50)	0.52 (0.50)	0.50 (0.50)
Rural	0.18 (0.39)	0.10 (0.30)	0.14 (0.35)	0.20 (0.40)	0.30 (0.46)

(continued)

Table 1 **(continued)**

	Full Sample	First Quartile: 0 to 1.25 CTE Units	Second Quartile: 1.25 to 2.5 CTE Units	Third Quartile: 2.5 to 4.5 CTE Units	Fourth Quartile: More Than 4.5 CTE Units
School demographic data					
Percentage free and reduced lunch	0.24 (0.25)	0.13 (0.20)	0.20 (0.23)	0.26 (0.24)	0.31 (0.24)
Percentage English language learner	0.04 (0.08)	0.03 (0.08)	0.05 (0.09)	0.05 (0.09)	0.03 (0.06)
School resources	0.03 (2.31)	0.34 (2.30)	0.06 (2.25)	–0.05 (2.28)	0.03 (2.25)
Environment					
Student morale	3.98 (0.76)	4.15 (0.76)	4.00 (0.74)	3.96 (0.75)	3.95 (0.73)
Teacher morale	3.80 (0.83)	3.97 (0.80)	3.82 (0.82)	3.76 (0.85)	3.71 (0.81)
School climate	–0.01 (2.28)	0.50 (2.38)	0.09 (2.33)	–0.19 (2.19)	–0.14 (2.00)

Note. All variables in this table are binary except for GPA, parent involvement, and extracurriculars (0 to 4 scales); math self-efficacy (1 to 4 scale); and school demographic and environment variables (continuous). CTE = career and technical education.

Benbow, 1990; Lee & Frank, 1990; Long, Conger, & Iatarola, 2012; Riegle-Crumb, 2006; Rose & Betts, 2004; Tyson, Lee, Borman, & Hanson, 2007; Wimberly & Noeth, 2005).[1] Included are results for the full sample, as well as breakdowns across quartiles of CTE unit completion. All control measures were drawn from base year surveys, except for ninth-grade GPA, which was sourced from the transcript files.

Demographic data included gender and race/ethnicity. The set of family data included parental status, parental education, and family income. Other control variables focused on measures of academic history and attitudes. Academic history was sourced from the transcript files and focused primarily on ninth-grade GPA. Ninth-grade GPA was selected as an appropriate proxy for achievement because it was available across all models with respect to timing, and it has also been found to be more strongly connected with college success than test scores (Allensworth, Gwynne, Moore, & de la Torre, 2014). While the potential for an endogenous relationship between ninth-grade GPA and CTE coursetaking does exist, we took this into consideration by testing our models without ninth-grade GPA as a covariate. There were no significant differences between the CTE coefficients returned from the models with and without ninth-grade GPA. We chose to retain ninth-grade GPA as a covariate in our models as it was a significant predictor of high school completion and dropout. We also included a measure of total academic units taken during a student's time in high school. This was a key covariate to take under consideration because of the relationship between academic coursetaking and CTE coursetaking that has been observed in previous studies (Plank et al., 2008). Academic attitudes included the following measures: the importance students place on education (binary), student expectations for college (binary), students' perception of math self-efficacy (4-point scale with 1 being lowest and 4 being the highest), students' perception of parental involvement (3-point scale with 1 being lowest and 3 being the highest), student employment outside of school (binary), and involvement in extracurricular activities (5-point scale with 0 being the lowest and 4 being the highest). Finally, we included the following school-level covariates: geographic region, urbanicity, school demographics (free and reduced lunch, English language learner [ELL], and school resources), and school environment (student morale and school climate). These variables were sourced from the base year survey.

Important to note is that across all high school years 9 through 12, only a small percentage (5%) of students did not enroll in a single CTE course in any given year. This helps to lessen any concerns that only the lowest achieving students were enrolling in these CTE courses and clarify that CTE was being accessed across the spectrum of student ability (Bozick & Dalton, 2013). In fact, prior research has shown that high school CTE courses are not geared toward higher versus lower achieving students (American Insititutes for Research, 2013). The fact that so many students completed

CTE coursework presents compelling evidence that CTE coursetaking was not a proxy for ability tracking. In fact, the correlation between the number of CTE units taken and student ninth-grade GPA (which was the earliest measure of performance given in the data set) was only −0.15.

While a vast majority of students tended to enroll in at least one CTE course over their time in high school, the patterns of CTE coursetaking in each specific year of high school were slightly different. Across individual years of high school, 52% of 9th-grade students did not complete any CTE, 51% of 10th-grade students did not complete any CTE, 42% of 11th-grade students did not complete any CTE, and 34% of 12th-grade students did not complete any CTE. Considering there are different CTE coursetaking patterns in specific grades, it becomes even more important to examine how the timing of these courses relates to later outcomes.

Analysis Plan

Baseline Model

For Research Question 1, the analysis began by estimating the following model:

$$y_{ist} = \alpha_s + \beta_1 CTE_{ist} + \beta_2 X_{i(t-1)} + \beta_3 J_{s(t-1)} + \varepsilon_{ist}.$$

In this equation, y_{ist} represents a binary variable indicating whether or not student i in high school s in survey wave t (i.e., at the end of high school) had dropped out of school. Since y_{ist} was a binary variable, we used a linear probability model to estimate the overall effects of completing additional CTE units. For each of the identified models, we used a probit model to estimate the changes in probability for a given outcome based on the observed independent variables. Note that for the purposes of the discussion in this section, we exemplify the analytic approach using dropout as the outcome.

CTE_{ist} represents the number of CTE units that a student took in high school; note that because so many students took at least one CTE course in high school, simply examining CTE coursetaking as a binary indicator would not provide useful information. $X_{i(t-1)}$ is a vector of all control variables measured in the baseline survey wave. The variable $J_{s(t-1)}$ represents a vector of school-level variables measured in the baseline survey wave. These variables are included to account for school differences that may affect student outcomes and abilities to enroll in CTE courses. Finally, the error term ϵ is estimated with standard errors adjusted for high school clustering given the fact that the sampling design of the data set entailed multiple students from the same school.

Research Question 2 relied on four separate models. Each of the models accounted for the specific grade in which a student completed his or her CTE coursework. The model was estimated as follows:

$$y_{ist} = \alpha_s + \beta_1 GRADECTE_{is(t-1)} + \beta_2 X_{i(t-1)} + \beta_3 J_{s(t-1)} + \varepsilon_{ist}.$$

In this model, $GRADECTE_{i(t-1)}$ represents the number of CTE units taken during a given year of high school, which we estimated for each 9th, 10th, 11th, and 12th grade. This model was estimated for each of the four high school years.

Note that Research Question 3 used identical models to those in Research Questions 1 and 2. However, in these models, the outcomes were those PSE outcomes as described previously. In these PSE outcome estimations, all students were included regardless of whether or not they completed high school.

Tests of Robustness

We employed an additional estimation strategy to examine the sensitivity of the findings from the baseline models due to the potential for omitted variable biases to have influenced relationships between CTE coursetaking and our set of outcomes. Given the touted purpose of CTE courses to link high school content to college and careers, students with a high degree of motivation to complete their degrees might be more inclined to take more of these courses. Therefore, we chose to use instrumental variable estimation to help reduce biases that may not have been fully addressed in our baseline models. An instrumental variable estimation strategy is a two-stage process. Each stage is represented by a unique regression. The first stage does not immediately evaluate the relationship between the outcomes and CTE coursetaking. Rather, the first stage in the analysis examines CTE coursetaking as the dependent variable. The first stage regression model is presented as the following:

$$CTE_{ist} = \beta_0 + \beta_1 IV_{it} + \beta_2 X_{i(t-1)} + \beta_3 J_{s(t-1)} + \varepsilon_{ist},$$

where CTE_{it} represents the original predictor of interest, which is the dependent variable in this first model. IV represents our instrumental variable. The final term is the error term clustered by school.

This instrument is an independent variable unique to the first-stage analysis. Our study is the first to employ an instrumental variables strategy to estimate the effects of CTE coursetaking. We drew on an instrument from prior studies that used national data sets to estimate the effects of other types of high school coursetaking, such as math courses (Altonji, 1995; Rose & Betts, 2004). Altonji (1995) examined the effect of coursetaking in various subjects—math, science, social studies, English, foreign languages—on wages. Utilizing subject-specific mean coursetaking in high school *s* for peers of student *i* as an instrument, Altonji (1995) was able to reduce the overestimation bias. Similarly, we chose the mean number of CTE units taken at school *s*, excluding the units taken by student *i* in school *s* as our instrument. Using the mean number of units as an instrument for student coursetaking is supported as allowing for a more clear-cut estimation of the effects of high school coursetaking net of ability and background (Rose & Betts, 2004). Previous use of this instrument has focused predominantly on the average peer units in required subjects (e.g., language arts, mathematics, science, etc.); CTE courses, on the other hand, are almost always elective courses. Therefore, our study provides a new application of this analytic approach.

There are two notes regarding this instrument. First, our instrument was the mean number of units at school *s* rather than the mean number of courses at school *s*, the second of which had been used in prior studies; courses can vary in length, and this would have overweighted a course that was a semester long rather than a full year. Second, we netted out a student's own number of CTE units from the value of the instrument. Had we not made this correction, the instrument would have been closely correlated with a student's error term, thereby returning us to the same problem we have tried to rectify.

In sum, we had the following variants on our instruments based on Research Questions 1 versus 2 to determine the effect of timing of completed CTE. The instrument for CTE units in each specific grade from 9th through 12th was the sample school average for students in that grade net of student *i*'s CTE units in the identified grade. For example, the instrument for 9th grade was the average number of CTE units completed by students at a school net student *i*'s CTE units.

In the second stage, the dependent variable was one of our original set of outcomes (e.g., high school dropout). They were each regressed on the predicted values of CTE units based on the first-stage regression, which included our instrument (9th-grade units, 10th-grade units, 11th-grade units, 12th-grade units, and total high school units). An important assumption to note was that our instrument was uncorrelated with any omitted variables. This assumption was supported as viable by Rose and Betts (2004), who examined math coursetaking on student outcomes; assuming it to be true here would imply that the second-stage predicted measure of CTE units would also be uncorrelated with omitted variables.

That said, just like Altonji (1995) and Rose and Betts (2004), the selection of our instrument is based on secondary data in which there was no natural or randomized experiment. While this quasi-experimental approach may indeed help reduce biases on our estimates of CTE coursetaking, it is possible that our estimates nonetheless remain biased. One reason might be that average CTE units taken at a school could affect outcomes for student *i* via school effects (e.g., more CTE units changing the general climate about the school or changing norms about college-going). Fortunately, general school climate is a measure in the data set based on school administrator responses;

the correlation between this measure and the average CTE units taken was −0.07.[2] We also correlated the average CTE units taken with school peer averages of various measures, such as average peer 9th-grade GPA (−0.07), average peer on-time graduation (−0.09), average peer dropout (0.13), average peer math performance (−0.15), and average peer parental involvement (−0.19). Therefore, we remain confident that our CTE instrument may not be correlated with observed aggregate school measures.

A second source of bias, however, may be that the average number of CTE units taken at the school level could be correlated with unobserved school-level factors. Given this, all models were subsequently run with school fixed effects (i.e., binary indictors that student *i* was in school *s*), which helped to ensure that all variation in CTE coursetaking occurs within rather than between schools. The results are practically identical to those presented throughout the article. Therefore, while not experimental, our instrumental variables strategy does help to lessen bias and nonetheless provides formative evidence of how CTE coursetaking is associated with our graduation and college-going measures.

We employed an additional test of robustness that took into account the fact that students choosing to drop out of school earlier would, by leaving high school early, not have had the opportunity to accumulate as many CTE credits. Through the use of Cox regression models, a common type of hazards model, we were able to more appropriately compare students as they progressed through time at school to observe the influence of time-varying early experiences (i.e., CTE completion) on later behaviors, such as dropout or on-time graduation (Plank et al., 2008). Such models are very useful for understanding the risk of a specific event occurring over time (Willett & Singer, 1991). Under this model, we estimate the risk that a specified outcome will occur at a specified time, provided it has not occurred prior to that time.

We used the following equation to estimate the Cox regressions:

$$h_i(t) = \lambda_0(t) exp\{\beta_1 CTE_{it} + \beta_2 X_i\}.$$

The equation states that the hazard for individual *i* dropping out of school (or graduating on time) at time *t*, provided that individual had not previously dropped out, is estimated by the product of two separate functions. The first function, $\lambda_0(t)$, is a baseline hazard function that is not necessarily specified. The second part of the equation is a linear function that includes both time-varying (e.g., CTE_{it}, which represents the number of CTE credits completed by student *i* up to time *t*) and fixed (e.g., various demographic variables) covariates. For these analyses, the risk period began with the first observation during the baseline survey of the student and ended when a student dropped out and did not return to school. It was also possible for the period to end with the successful receipt of a high school diploma. The unit of time in the analysis was the number of semesters of school completed prior to dropping out of high school. We estimated a separate model for each of the CTE time periods of interest—early/late and by specific grade level.

Results

Main Findings

Dropout

Our first research question inquired into whether CTE unit completion in general was linked to dropout. The first model focused on this—CTE units completed across the high school time span. Our second research question inquired into timing of when these CTE units were taken. The remaining estimations (Models 2–5) present a breakdown of CTE unit completion by timing. Each model represents a CTE coursetaking in a specific year of high school.

Table 2 presents the estimates for high school dropout for our main independent variables of CTE coursetaking as well as for each of the covariates as identified previously. The coefficients are presented as changes in probabilities, with negative coefficients indicating a decrease in the probability of an outcome and positive coefficients indicating an increase. With respect to high school dropout, a negative coefficient represents the desired result.

In regards to Research Question 1 (Model 1), taking a greater number of CTE units across Grades 9 through 12 was associated with a lower chance of dropping out. As exemplified in our Model 1, a coefficient of –.012 corresponds to a decreased probability of dropout of 1.2% per unit of CTE completed across high school. Models 2 through 5 addressed our second research question pertaining to the timing of when the units of CTE were taken during high school. The results suggest that late CTE unit completion is more strongly associated with reduced chances of high school dropout. While including early coursetaking in either the 9th (Model 2) or 10th grade (Model 3), the resulting coefficients were both nonsignificant. However, in Models 4 and 5, we found that late CTE unit completion was significant in both models. In Model 4, 11th-grade CTE was associated with a decreased probability of dropout of 1.6% per CTE unit. Twelfth-grade CTE was also associated with a similar decrease in dropout probability of 1.6%.

Overall, Table 2 presents promising evidence that there exists a link between increased CTE units completed and a reduction in the probability of dropping out of high school. Even with a wide span of control variables, the association between CTE unit completion and dropout remained significant. While not a direct focus of the study, it was noteworthy that many controls were statistically significant and in the direction that was consistent with previous literature. For instance, gender and race variables were statistically

Table 2
Probit Model Results Predicting High School Dropout

	(1) Dropout	(2) Dropout	(3) Dropout	(4) Dropout	(5) Dropout
Total CTE units	−0.012***				
	(0.00)				
9th-grade CTE units		0.000			
		(0.00)			
10th-grade CTE units			−0.003		
			(0.00)		
11th-grade CTE units				−0.016***	
				(0.00)	
12th-grade CTE units					−0.016***
					(0.00)
Student level					
Demographic data					
Gender (female)	−0.008	−0.008	−0.008	−0.005	−0.005
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Race/ethnicity					
Black	−0.006	−0.004	−0.004	−0.004	−0.003
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Hispanic	−0.006	−0.005	−0.006	−0.002	−0.001
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Asian	−0.010	−0.008	−0.009	−0.006	−0.004
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Family data					
Family arrangement					
Single-parent household	0.012*	0.013*	0.013*	0.011*	0.013*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

(continued)

Table 2 **(continued)**

	(1) Dropout	(2) Dropout	(3) Dropout	(4) Dropout	(5) Dropout
Other arrangement	0.016**	0.020***	0.020***	0.015**	0.016**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Highest parental education					
High school or less	0.008	0.006	0.006	0.006	0.006
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
BA degree or more	−0.014*	−0.013*	−0.014*	−0.011	−0.010
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Family income					
Lowest 25%	0.008	0.012*	0.012*	0.008	0.009
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Highest 75%	−0.007	−0.004	−0.004	−0.006	−0.006
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Academic history and attitudes					
Student GPA	−0.026***	−0.036***	−0.036***	−0.036***	−0.036***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Academic units	−0.011***	−0.009***	−0.010***	−0.017***	−0.016***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Importance of education	0.002	0.004	0.004	0.003	0.002
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Math self-efficacy	0.002	0.006	0.006	0.004	0.002
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Parent involvement	−0.017**	−0.021***	−0.021***	−0.016**	−0.016**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Employed outside the house	0.007	0.013*	0.012*	0.013*	0.013*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

(continued)

Table 2 **(continued)**

	(1) Dropout	(2) Dropout	(3) Dropout	(4) Dropout	(5) Dropout
Involved in extracurricular activities	−0.009***	−0.012***	−0.012***	−0.008***	−0.008***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Postsecondary expectations					
Any college	−0.013*	−0.020**	−0.020**	−0.013*	−0.013
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Completed four-year degree or more	−0.034***	−0.038***	−0.038***	−0.029***	−0.029***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
School level					
Region/urbanicity					
Northeast	−0.008	−0.006	−0.008	−0.011	−0.011
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
West	0.009	0.019*	0.018*	0.018*	0.016*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
South	0.016*	0.017*	0.017*	0.012	0.012
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Urban	−0.006	−0.001	−0.002	−0.007	−0.007
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Rural	0.005	0.005	0.005	0.005	0.002
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
School demographic data					
Percentage free and reduced lunch	0.007*	0.007*	0.007*	0.006*	0.005
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Percentage English language learner	0.002	0.002	0.002	0.004	0.004
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

(continued)

Table 2 **(continued)**

	(1) Dropout	(2) Dropout	(3) Dropout	(4) Dropout	(5) Dropout
School resources	0.004	0.003	0.004	0.003	0.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Environment					
Student morale	−0.001	−0.001	−0.000	−0.000	−0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
School climate	0.004	0.002	0.002	0.004	0.003
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
N	10,940	10,940	10,940	10,940	10,940

Note. Robust errors adjusted for school clustering presented in parentheses. CTE = career and technical education.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3
Probit Model Results Predicting On-Time High School Graduation

	(1) On-Time Graduation	(2) On-Time Graduation	(3) On-Time Graduation	(4) On-Time Graduation	(5) On-Time Graduation
Total CTE units	0.016*** (0.00)				
9th-grade CTE units		−0.001 (0.00)			
10th-grade CTE units			0.007** (0.00)		
11th-grade CTE units				0.015*** (0.00)	
12th-grade CTE units					0.016*** (0.00)
N	10,460	10,460	10,460	10,460	10,460

Note. Robust errors adjusted for school clustering presented in parentheses. Each model includes all control variables from Table 1. CTE = career and technical education.
$^{**}p < .01$. $^{***}p < .001$.

significant in the anticipated direction (Alexander, Entwisle, & Horsey, 1997). Second, students in families with alternative parental arrangements (i.e., as compared to living with both biological parents) were more likely to drop out (Alexander et al., 1997; Astone & McLanahan, 1994). Next, household income and parental education were associated with odds of dropout—students from families with higher income and more parental education were less likely to drop out of high school (Alexander et al., 1997; Battin-Pearson et al., 2000; Jimerson, Egeland, Sroufe, & Carlson, 2000). Finally, academic history and attitudes significantly predicted differential odds of dropping out: Higher postsecondary expectations, increased academic unit completion, and perceptions of parental involvement were associated with lower probabilities of high school dropout (Jimerson et al., 2000; Vallerand, Fortier, & Guay, 1997).

On-Time Graduation

As defined previously, on-time graduation measured whether a student received a high school diploma within four years of beginning high school. The results are presented in Table 3.

As with the models on dropout, Model 1 tested for an association between the number of CTE units across all years of high school and the probability of on-time graduation. Models 2 through 5 addressed timing of when students had taken these units. All coefficients are presented as probabilities, and clustered standard errors are in parentheses.

Similar to the conclusions from analyzing high school dropout, the results in Table 3 demonstrate a promising pattern for students who enrolled in CTE units in high school in regards to on-time high school graduation. Model 1 shows that across all of high school, students have a higher probability of on-time graduation by 1.6% for every CTE unit completed in high school. Similar to dropout, there is a stronger predicted link between number of CTE units taken in late high school grades compared to both the aggregate number of units across Grades 9 through 12 and the number of units completed in early high school grades. The probability associated with early CTE in the 9th grade is once again nonsignificant, but 10th-grade CTE was associated with an increased probability of 0.7% of on-time graduation. Similar to dropout, late CTE is significant in Models 4 and 5. Model 4 presents evidence that 11th-grade CTE completion is associated with an increased probability for on-time graduation of 1.5% per CTE unit, while Model 5 also shows a positive relationship between 12th-grade CTE and on-time graduation, with an increased probability of 1.6%. Hence, it does appear that later CTE coursetaking has a stronger link to end of high school outcomes.

Test of Robustness

The aforementioned models present findings based on having controlled for a wide array of student and family characteristics. One concern, however, was selection and individual-level omitted variable bias. It might have been the case that for unobserved reasons, students had selected to take more CTE units or that families and students were selecting to attend a school because of the span of CTE curriculum. If this were the case, then the previous set of estimates would be biased.

To address this, we employed an instrumental variables strategy. Recall that we had five separate models based on the timing of CTE coursetaking—labeled Models 1 through 5 in all prior tables. Therefore, our instrumental variables estimation was run separately for each CTE timing measure, meaning that there was a separate, related instrument for each model as described previously.

Table 4 presents the first stage results for each of our instruments. In the first stage, the dependent variable was the number of CTE units that student *i* had taken, while the independent variables included the instrument as well as all other observed covariates and an error clustered at the school level. For clarity, only the results for the instruments are presented here. In the first-stage regressions, each of the instruments had a strong statistically significant relationship with the first stage outcome. Controlling for all else, a public school with students taking, on average, more CTE units was linked to an individual's own increased CTE coursetaking. This first stage finding was in the hypothesized direction and was consistent with prior research that utilized an analogous instrument to estimate the effect of other types

Table 4

Instrumental Variable First-Stage Regression Estimates

	First-Stage Outcomes				
	CTE Units 9th Through 12th Grades	CTE Units 9th Grade	CTE Units 10th Grade	CTE Units 11th Grade	CTE Units 12th Grade
Instrument: Mean CTE units 9th through 12th grades	0.88*** (0.03)				
Instrument: Mean CTE units 9th grade		0.87*** (0.02)			
Instrument: Mean CTE units 10th grade			0.84*** (0.03)		
Instrument: Mean CTE units 11th grade				0.78*** (0.02)	
Instrument: Mean CTE units 12th grade					0.83*** (0.02)
F statistic	67.92***	98.83***	65.47***	66.52***	61.09***
n	10,940	10,940	10,940	10,940	10,940

Note. Robust errors adjusted for school clustering presented in parentheses. Estimations include all covariates listed in Table 1. CTE = career and technical education.
***$p < .001$.

(i.e., math) of coursetaking (Altonji, 1995; Rose & Betts, 2004). To ensure our results were not being influenced by extremely high or extremely low values of mean CTE units completed by classmates, we trimmed 10% from both the top and bottom of the sample and reran our IV models. Using the trimmed sample so that we only examined the 10th to 90th percentile, the results were generally consistent in removing the tail ends of the distribution of mean CTE units. Therefore, we feel confident in the results for our full analytic sample.

Table 5 shows the second-stage results for dropout and on-time graduation. Here, these outcomes were regressed on the predicted value of CTE units attained from the first stage regressions as well as all control variables. The sizes of the coefficients are quite similar to our initial models, though 10th-grade CTE unit completion became nonsignificant. Additionally, later high school CTE coursetaking was associated with nearly identical coefficients for 11th-grade (1.6% decrease in probability of dropout and 1.5% increase in probability of on-time graduation) and slightly larger coefficients for 12th grade (1.8% decrease in probability of dropout and 2.1% increase in probability of on-time graduation). Students taking more CTE units across all high school continued to exhibit lower probabilities of dropout (1.1%) and increased probabilities of on-time high school completion (1.5%).

Hazards Model

Using the last semester a student attended school as the timing measure for our survival analysis, we were better able to see the role of CTE coursework at different periods across high school for students. Once again, CTE unit coursetaking was estimated for the entire high school career as well as the units completed in each specific grade. Table 6 presents the results for our analyses looking at both dropout and on-time graduation. An important note on the results and interpretation of survival models is that not all students progress through to each given year, and therefore the results indicate a change in probability for students who successfully advanced to a given level of high school.

The results continue to support those in previous models that for students advancing beyond the 9th grade, later high school CTE does play a key role in helping decrease the probability of dropout and increase the probability of graduation on time. Under the hazards model, CTE across all high school was significantly related to lower probability of dropout at 14.6% per unit and on-time graduation at 17.4% per unit. CTE courses taken in either 9th or 10th grade were not significantly related to dropout or on-time graduation. However, both 11th-grade and 12th-grade CTE remained significantly related to both dropout (20% and 29.9%, respectively) and on-time graduation (19.8% and 28.2%, respectively). It is important to keep in mind that by the time 11th- and 12th-grade CTE credits were

Table 5
Marginal Effects From Probit Models of Instrumental Variable Estimation

	(1) Dropout	(2) Dropout	(3) Dropout	(4) Dropout	(5) Dropout	(6) Dropout
Total CTE units	−0.011**					
	(0.00)					
9th-grade CTE units		−0.001				
		(0.01)				
10th-grade CTE units			0.002			
			(0.01)			
11th-grade CTE units				−0.016*		
				(0.01)		
12th-grade CTE units					−0.018**	
					(0.01)	
N	10,940	10,940	10,940	10,940	10,940	
	(6) On-Time Graduation	(7) On-Time Graduation	(8) On-Time Graduation	(9) On-Time Graduation	(10) On-Time Graduation	
Total CTE units	0.015***					
	(0.00)					
9th-grade CTE units		−0.000				
		(0.01)				
10th-grade CTE units			0.001			
			(0.01)			
11th-grade CTE units				0.015*		
				(0.01)		
12th-grade CTE units					0.021**	
					(0.01)	
N	10,460	10,460	10,460	10,460	10,460	

Note. Robust errors adjusted for school clustering presented in parentheses. Each model includes all control variables from Table 1. CTE = career and technical education.
*$p < .05$. **$p < .01$. ***$p < .001$.

accumulated, a number of students had already dropped out of high school. Fortunately, the hazards models take this into consideration.

These results are consistent with those found by Bozick and Dalton (2013) in an earlier report. However, our results build on those prior findings by showing that a majority of the benefit gained from CTE participation is through CTE coursetaking later in high school. These results further indicate it is necessary to take into account when a student left school when considering the relationship between credit completion and dropout.

Table 6
Hazards Model Results Predicting Dropout and On-Time Graduation

	(1) Dropout	(2) Dropout	(3) Dropout	(4) Dropout	(5) Dropout
Total CTE units	−0.146*** (0.022)				
9th-grade CTE units		0.031 (0.030)			
10th-grade CTE units			−0.007 (0.026)		
11th-grade CTE units				−0.199*** (0.033)	
12th-grade CTE units					−0.299*** (0.046)
N	10,380	10,380	10,380	10,380	10,380
	(6) On-Time Graduation	(7) On-Time Graduation	(8) On-Time Graduation	(9) On-Time Graduation	(10) On-time GRADUATION
Total CTE units	0.174*** (0.024)				
9th-grade CTE units		−0.048 (0.034)			
10th-grade CTE units			0.022 (0.031)		
11th-grade CTE units				0.198*** (0.037)	
12th-grade CTE units					0.282*** (0.046)
N	10,380	10,380	10,380	10,380	10,380

Note. Robust errors adjusted for school clustering presented in parentheses. Each model includes all control variables from Table 1. CTE = career and technical education.
***$p < .001$.

Additional Measures of Attainment

Table 7 presents the baseline and instrumental variable estimates for college-going behaviors exhibited by students taking CTE units at any point in high school, early in high school, and late in high school. Each of the college-going behavior models contained binary outcomes and was estimated using linear probability models. Each model factored in the same control variables in sociodemographic, academic, and school-level categories as in previous models, though they are not presented here for clarity.

Regarding college-going behavior, we can see that CTE unit completion is generally not linked to college-going behaviors. However, the results suggest a positive significant link between 11th-grade CTE coursetaking and both probability of enrollment within two years (0.8%) and probability of ever enrolling in postsecondary education (0.8%). Taking more CTE in 12th grade also exhibits a small significant improvement in probability of applying to PSE (0.9%). There were no significant results showing a link between CTE and enrolling in PSE immediately after high school. These results imply that CTE may not be strongly associated with later college-going behaviors, but it also does not appear to have any negative influence on a student's decision to pursue further education beyond high school.

Discussion

Federal policy has continued to charge forward with redeveloping and reauthorizing a CTE curriculum that emphasizes relevant and engaging content in high school (Perkins IV). Traditional material is often taught in silos where concepts often remain abstract or theoretical with little attention paid to the practicality of the content (Gottfried et al., 2016). However, this has been changing: Through CTE coursework, students might be better positioned to connect traditional school material with how it relates to opportunities beyond the classroom in either postsecondary education or employment (i.e., through CTE). This may be especially critical for students at risk of high school dropout—linking educational content with practical experiences might help to solidify the relevance to keep students on track for graduation. However, prior to this study, little research had examined how CTE unit completion predicted dropout or high school graduation; additionally, no work had considered the effect of timing of when CTE units were taken, and no work had linked this to college-going behaviors.

We consider this an oversight in the research field. Given that the explicit purpose of the CTE curriculum is to increase the relevance of school material (NAVE Independent Advisory Panel, 2004), it is surprising that previous studies have not examined outcomes that directly represent educational engagement across the high school to college pipeline. When students drop out of high school, they most often cite school-related reasons—generally they express a dislike of school, implying a lack of engagement and lack of perceived relevance (Rumberger, 2001). Therefore, CTE coursework might serve as one way for students to access high school material in a way that makes school more relevant and engaging. Students in CTE courses might be more likely to make the connection between traditional concepts and future opportunities beyond high school, thereby increasing their likelihood to view the importance of persisting through high school.

Based on our analyses, the answers to our research questions were quite clear. As for the first research question, students who completed a greater

Table 7
CTE Coursetaking on Other Educational Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Applied to Postsecondary Institution					Enrolled in Postsecondary Institution Immediately after High School				
Total CTE units	0.001					−0.002				
	(0.00)					(0.00)				
9th-grade CTE units		−0.004					−0.004			
		(0.00)					(0.00)			
10th-grade CTE units			−0.003					−0.005		
			(0.00)					(0.00)		
11th-grade CTE units				0.005					−0.003	
				(0.00)					(0.00)	
12th-grade CTE units					0.009**					−0.001
					(0.00)					(0.00)
N	9,400	9,400	9,400	9,400	9,400	10,090	10,090	10,090	10,090	10,090
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
	Enrolled in Postsecondary Institution Within Two Years of High School					Ever Enrolled in Postsecondary Institution				
Total CTE units	0.000					0.000				
	(0.00)					(0.00)				
9th-grade CTE units		−0.005					−0.004			
		(0.00)					(0.00)			
10th-grade CTE units			−0.001					−0.001		
			(0.00)					(0.00)		
11th-grade CTE units				0.008*					0.008*	
				(0.00)					(0.00)	
12th-grade CTE units					0.003					0.004
					(0.00)					(0.00)
N	9,500	9,500	9,500	9,500	9,500	9,470	9,470	9,470	9,470	9,470

Note. Robust errors adjusted for school clustering presented in parentheses. Each model includes all control variables from Table 1. CTE = career and technical education.
$*p < .05$. $**p < .01$.

number of CTE units were less likely to drop out of high school and were more likely to graduate on time. This is a critical finding because it provides evidence that CTE coursework may be helping students be more successful in high school as measured by completion. One of the potential explanations for the reduction in high school dropout through participation in CTE coursework could be the promotion of engagement. As Rumberger (2001) pointed out, dropping out is the end result of years of disengagement with education. CTE courses may be alleviating these feelings of disengagement and helping to bring students back into the educational fold.

As for the second research question, timing matters. Taking more CTE units later in high school (i.e., Grades 11 and 12) was linked to lower odds of high school dropout (i.e., the effect sizes were larger). However, the observed patterns between early CTE coursetaking (i.e., Grades 9 and 10) and the chances of dropout were generally quite small. When accounting for both early and late high school CTE coursetaking in the same model, completion of units later in high school overshadowed any effect of taking CTE early in high school. Taking both early and late CTE units were linked to higher chances of on-time high school graduation. Though the number of CTE units taken in both periods was statistically significantly related to on-time graduation, the effect sizes were larger for later CTE coursetaking compared to earlier CTE coursetaking. As with dropout, the interpretation of the findings was consistent across all approaches, though the results were slightly tempered in the instrumental variables approach.

As our framework speculated, late school coursetaking exhibits stronger effects in relation to both dropout and on-time graduation. As students approach high school graduation, they must contemplate their options for after graduation. CTE offers an option that is not necessarily reliant on further education (though it can be) and therefore may appeal to many students as a way to gain important skills that will be directly relevant after high school. While on-time graduation was also associated with higher effect sizes from later courses, it is interesting to note that there was a significant effect from early high school coursetaking. This implies that on-time graduation can be impacted both by late school relevance as well as the scaffolding that took place earlier in the high school career.

Our third research question inquired into college-going behaviors. The findings indicated that CTE coursetaking was associated with lower odds of enrollment in PSE or that the findings were null. Therefore, while our findings speak to reduced odds of dropout and increased odds of on-time graduation, there was not a positive link to college-going behavior. The domain of the influence of CTE coursetaking, in other words, was fairly specific to high school outcomes. As students completing CTE courses go on to graduate high school, they find themselves in a position to immediately enter the labor force thanks to skills gained from CTE coursework. This might actually reduce the perceived necessity to enter college.

Based on these findings, there are several overarching implications. First, our study does suggest one policy lever to smooth the transition out of high school. That is, it seems that CTE coursetaking—particularly when later in high school—might have the potential to reduce dropout behaviors and promote on-time graduation. This lends support to the idea of further expansion of CTE coursework in high school. While CTE did not necessarily increase PSE behaviors, perhaps a more relevant goal for high school CTE is the promotion of student engagement and relevance in high school to address critical proximal outcomes with which our nation is still grappling.

Next, this study brought forth the idea that the timing of CTE coursetaking influences student outcomes. With this in mind, it may be helpful for schools and districts to consider how early and late CTE coursetaking might capture the benefits of dropout reduction at different stages of high school. Finally, our study showed that CTE coursetaking did not necessarily link to college-going behavior. Instead, the positive consequences of CTE coursetaking were domain-specific to high school. The lack of a positive link to postsecondary outcomes in this study is noteworthy, particularly given that one purpose of high school CTE coursetaking is to smooth the transition to college (Partnership for 21st Century Skills, 2010). Therefore, the lack of any observed smoothed transition calls for the need for further assessment of the reach of high school CTE coursetaking if indeed policymakers wish to more effectively rely on CTE to address college-going gaps.

There were some limitations to this study. One limitation was that we did not have direct measures of engagement. Instead, we relied on proxy measures of educational engagement, such as dropout, high school completion, and PSE. While these were important outcomes to consider given their economic and educational implications, future research may take this into consideration through more directly measuring engagement or collecting further engagement measures.

Another potential limitation was that we did not have complete view on what was actually being taught in each of these courses. Having an understanding of specific material or instructional practices would further develop the linkage between CTE and high school outcomes.

Fourth, as noted, our work was based on nonexperimental data. While our analytic approach may have helped reduce biases in the observed associations between CTE coursetaking and our set of outcomes, nonetheless the results should not be interpreted as causal. With the foundation of knowledge based on these findings, however, future research might develop an experimental design with a focus on CTE content and measured student engagement as a potential outcome. Doing so will help flesh out the findings in this study and build programs that best prepare our students for educational success.

Finally, the data set used in this study represents a nationally representative snapshot of students who were in 10th grade when NCES began collecting data. While we do have full transcript information, there are for obvious reasons no sample members who dropped out of high school in 9th grade. Therefore, while the study profiled sophomores as they progressed through school, it was not possible to identify patterns of any peers who might have dropped out prior to the survey administration. While dropout rates are the lowest in 9th grade compared to any other year in high school according to the U.S. Department of Education (2012), future research might nonetheless rely on a data set that begins with 9th grade so it would be possible to examine dropout in each year of high school.

In sum, in looking at the connection between high school coursework and high school dropout, this was the first study to examine the timing of these courses and their relevance to these outcomes. Students often become disengaged with more traditional academic courses because they are not able to make a direct connection to their longer term goals in college or career, thereby increasing chances of dropout (Stone & Lewis, 2012). By providing CTE coursework, especially later in a student's high school career, relevance between coursework and long-term goals is potentially increased, thereby increasing the odds of high school graduation. While this study presents the possibility that there remains some disconnect with college enrollment, it also shows that the push to increase the academic rigor through actions such as the Perkins IV has begun to bridge this gap and encourage students to become both career and college ready.

Notes

[1]While Plank, DeLuca, and Estacion (2008) found an indicator for age to override any benefits gained from participation in career and technical education (CTE), we examined age in our analysis and found it to be a nonsignificant predictor in relation to dropout and high school completion. It was therefore not included in our analyses.

[2]School climate was created by the National Center for Education Statistics and included the following response items from school administrators: Student morale is high, teachers press students to succeed, teacher morale is high, learning is high priority for students, and students are expected to do homework.

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