



Improving Measurement in Career and Technical Education to Support Rigorous Research

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Abstract

Nationwide in 2013, more than half of all high school graduates (58%) earned two or more credits in a career and technical education (CTE) subject area. Among college students, more than two thirds of all undergraduate credentials (68%) were awarded in an occupational area. Yet although CTE is well subscribed, little is known about the efficacy of this programming. Most studies of CTE have not used research designs that support causal inference, relying instead on information from nationally representative or statewide datasets to estimate relationships between students' CTE course taking and subsequent education and employment outcomes. These studies tend to associate students' in-school experiences and postprogram results with levels of credit accumulation, but they do not account for other measures of experience that educators and policymakers argue are likely to contribute to any potential impact. As a result, the literature has failed to fully capture the effect that CTE programming has on individuals who concentrate their studies in a comprehensive, high-quality CTE program of study. Reauthorization of federal CTE legislation and increasing attention to the career preparation of youth will continue to draw attention to the field; for this reason, there is a need to strengthen the rigor of CTE research to estimate the impact of CTE exposure on students. We catalog the measures of CTE exposure used in prior studies, document measures and outcomes in more recent causal studies, and offer a framework for how to measure CTE exposure and outcomes in the future to contribute to this work.

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1. Introduction

For more than a century, career and technical education (CTE) has occupied a formal place in public education, but in the last decade, CTE has seen a resurgence in relevance and policy focus. The recent rise in interest has, in part, been in response to mixed results from the earlier focus on college-for-all in secondary education (Rosenbaum, 2004; Stringfield & Stone, 2017). Although economic returns to baccalaureate degrees persist, low completion rates and high debt accumulation have highlighted policy challenges at the postsecondary level. At the same time, strong labor markets have highlighted the shortage of skilled workers in career fields that do not require a bachelor's degree.

The July 2018 reauthorization of the Strengthening Career and Technical Education for the 21st Century Act (Perkins V) refocused states' attention on CTE programming offered at the secondary and postsecondary levels. Although it retained many key provisions of the preceding legislation (Perkins IV), Perkins V introduced several new expectations relating to program design and delivery, along with changes to the accountability system for assessing grantee performance. To qualify for federal funding, states had to develop and submit by April 2020 a 5-year state plan that detailed their approach to the new legislation.¹ Many states used this opportunity to update their own strategic plans for administering CTE; consequently, the landscape of CTE offerings underwent significant change in many states.

As CTE grows to occupy a larger share of the education policy conversation, it is important to consider what we know about the efficacy and impact of CTE to inform changes in policy and practice. This includes being deliberate in our approach to measuring students' CTE experiences and specifying the outcomes that we expect to be most responsive (Wilkie, 2019; Wolf, 2018).

This paper has two goals. The first goal is to document how CTE has been measured in empirical quantitative research in the last 20 years and how these measurement approaches inform our understanding of CTE's impacts. Given that most of these studies do not have counterfactual conditions that can support causal inference, we focus instead on the ways in which the characterization of CTE has been recorded. The second goal is to highlight the limitations of how CTE was measured in past research and make recommendations about what elements of the CTE experience should be measured in future research and why. Specifically, we aim to present options for how to operationalize elements to maximize understanding of the impact of CTE on students, as well as the mechanisms that might explain those impacts (or lack thereof). Further, we suggest the importance of focusing on equity when measuring CTE experiences (even in a way limited by the structure of most quantitative data), namely by considering the heterogeneity of students both within programs and among those who do and do not select into CTE programs. Expanded data access, the adoption of state longitudinal data systems (SLDS), and changes in how and where CTE instruction is delivered make this work important and timely.

The paper opens by describing the process we used to catalogue quantitative research and the metrics used to assess student experience and outcomes in prior scholarship. We then describe the findings of our analysis of this compiled data before highlighting the gaps and limitations in these earlier approaches. Next, we propose a set of metrics to better capture CTE experiences. The goal of these proposed measures is to highlight dimensions of experience that may be used to contrast the experiences of students who participate in CTE at the secondary and postsecondary levels with those who do not. These metrics also allow for distinctions among the different types of CTE experiences (e.g., work-based learning [WBL]) in which students engage. We conclude with a

¹ The April deadline was extended to September 30 to provide flexibility to states facing COVID-19-related challenges.

discussion of how new policies and growth in CTE programming and funding might inform future scholarship and the measures to be employed in such research.

1.1 Why High-Quality CTE Research Matters

As causal program evaluation has become the norm throughout education and public policy research, causal research on the effectiveness of CTE programs has been slower to emerge. Several elements account for the lack of rigor in published literature. First, most studies are based on descriptive data that do not support causal evaluation. Furthermore, because of data limitations, many employ coarse measures of CTE exposure and experience, such as the number of technical credits or courses completed, which fail to account for the full experience that a comprehensive CTE program may provide. Finally, short study windows do not provide sufficient time to observe the contribution to career readiness that CTE may confer. Among the studies that support causal impact estimates, all have been conducted in settings that do not generalize to the way that CTE is most commonly offered. Consequently, relatively little is known about how CTE participation contributes to student in-school achievement and subsequent postsecondary education and labor market success. Improving how CTE exposure is measured and the outcomes used to assess its effects could go a long way toward improving what we know about CTE experiences and impacts, whether in descriptive or causal studies.

The fact that students choose CTE based on interest or other personal considerations means that in nearly all instances, the individuals who choose to concentrate their studies in CTE differ from those who did not in important ways. Those differences, almost by definition, cannot be observed, meaning that most attempts to quantify the impacts of CTE leave large concerns about omitted variables bias (or confounding variables, in some disciplines). The few experimental or quasi-experimental impact evaluations of CTE were in settings where students are admitted to specialized career-themed schools or groupings within larger schools, where all instruction, both academic and technical, is offered to all students using an integrated curriculum. Moreover, these studies have been limited in their ability to differentiate the elements of the experience at those schools that might explain the effects, or absences of effects, of being admitted to them.

Most of the extant research focused on the efficacy of CTE course taking outside specialized CTE schools or pathways within larger high schools used definitions of CTE exposure that align with the requirements for states to receive federal funding through the Carl D. Perkin's block grant program. Thus, these papers account for differences in the volume of course taking, and in some instances the general program areas that define the substance of those courses, but not elements of the experiences that students have in high school that most CTE educators and policymakers think are vital. One structural challenge is that states' definitions relating to the intensity of student participation and indicators used to assess performance vary considerably, so there often is little ability to establish comparability in findings across states. The larger problem is that nearly all prior studies are descriptive, suffer from selection bias, and seek to account for the totality of the experience without considering different programmatic elements (e.g., dual credit, industry-recognized credentials, pathway specializations, WBL, career exploration and planning). Simple measures of CTE exposure or dosage, coupled with the absence of robust follow-up data, limit the value of these studies to inform CTE policy and practice.

Beyond problems of self-selection and omitted variables bias, the second largest challenge to CTE research has been a reliance on a fairly limited definition of what constitutes CTE exposure. That is (as documented later), most studies measure CTE experiences in high school based solely on the number of credits or courses that a student took. This practical adaptation to the accessibility of student transcripts, whether collected by researchers themselves or as part of national datasets, is analogous to how researchers have looked at associations between mathematics course taking and subsequent academic or life outcomes. However, such a limited approach misses important elements that distinguish CTE experiences from the most likely counterfactual. Whether and how CTE

participation has impacts may relate to not only course taking but also other elements of the experience, which may differ depending on the setting where students are learning and other co-curricular structures that are designed to complement course taking.

2. Previous Measurement of CTE in the Scholarly Literature

Using citations from recently published causal evaluations of CTE and lists provided by a team of experts in CTE policy and scholarship, we compiled 30 papers that assessed the relationship between CTE participation in high school and graduates' subsequent postsecondary education and employment outcomes. The papers were written from 1986 to 2019, and were published either in peer-reviewed journals or by well-regarded research organizations. We coded each quantitative paper based on its methodology, data/sample, measure(s) of CTE exposure, key covariates, and outcome measures. We then expanded on those metrics to include codes for how each paper defined a CTE "concentrator,"² noted whether the study defined subject-oriented subgroups of courses (CTE or otherwise), and logged the stated rationale for defining those categories.

After capturing a wide swath of descriptive data about each paper, we developed binary indicators for some categories. For example, to code study data sources, we generated a list of the most commonly used national datasets and then created binary variables that were set to a value of "one" for papers using that dataset. We used a similar process to construct indicators for when studies used SLDS.

We repeated this process to categorize other indicators, including categories of exposure, CTE course groupings, definitions of concentrator, and outcome metrics. Within each category, the most commonly cited results became binary indicator variables. We categorized almost all of the 30 papers' outcomes into five categories; a similar method was used for other data categories. The entries in each column of Exhibit 1 directly correspond to those binary indicators.

Analysis of the coded data revealed a number of interesting patterns in the extant literature. Most notably is that despite the diverse offerings of CTE programs, the modal mechanism for measuring CTE exposure is some form of high school CTE course taking. The most commonly used metric (16 of 30 studies) is the number of courses taken, which was sometimes implemented as a continuous measure of exposure and sometimes used to develop categorical levels (e.g., zero courses, one to two courses, three or more courses). Largely dependent on the dataset, courses taken are generally defined by the number of credits earned, the number of "years" in which a student participated in CTE coursework, and/or the total number of CTE courses listed on a student's transcript. Some papers also considered a given student's ratio of CTE courses to non-CTE courses as a continuous measure (six of the 30 studies) to account for differences in total course taking across schools, districts, and states. Other papers defined exposure as attendance at a CTE-focused school (four of the 30 studies) or the completion of a specific CTE-related track (seven of the 30 studies) within a school. Lastly, a handful of papers (six of the 30 studies) included definitions of CTE exposure as noncourse CTE experiences, such as participation in an internship program or paid employment experience in conjunction with their high school curricula, although the majority of those papers (five of the six studies) also used other definitions of exposure.

² Students who participate in CTE may complete differing numbers of courses or credits. For measurement purposes, states often establish a minimum threshold of CTE credit or course taking accumulation in a single CTE program area to signify that a student has achieved some measurable benefit. Perkins V, for example, explicitly defines a concentrator as a "student . . . who has completed at least 2 courses in a single [CTE] program or program of study" (Section 3[12]). In practice, however, states and researchers may set different thresholds or apply differing criteria to make this assignment.

Exhibit 1. Summary of Papers

Author and Year	Title	Data source	Measures of exposure	Outcome
Agodini and Deke (2004)	The Relationship Between High School Vocational Education and Dropping Out	NELS-88	Number of courses taken; ratio of CTE to non-CTE coursework	High school graduation
Ainsworth and Roscigno (2005)	Stratification, School-Work Linkages and Vocational Education	NELS-88	Number of courses taken; other noncourse CTE experiences	High school graduation
Bishop and Mane (2010)	Raising Academic Standards and Vocational Concentrators: Are They Better Off or Worse Off?	NELS-88	Concentrator status; number of courses taken	Other academic (HS); postsecondary attainment
Bishop and Mane (2004)	The Impacts of Career-Technical Education on High School Labor Market Success	NELS-88	Ratio of CTE to non-CTE coursework	Labor market
Bonilla (2019)	Connecting High School, College and the Labor Market: Evidence on the Scale-Up of Career Pathways in California	State-specific data	Track/program completion	School-level outcomes
Bozick and Dalton (2013)	Balancing Career and Technical Education With Academic Coursework: The Consequences for Mathematics Achievement in High School	ELS-2002	Concentrator status	Other academic (HS)
Brunner, Dougherty, and Ross (2019)	The Effects of Career and Technical Education: Evidence From the Connecticut Technical High School System	State-specific data	Attendance at a CTE school	High school graduation; other academic (HS); postsecondary attainment; labor market
Catterall and Stern (1986)	The Effects of Alternative School Programs on High School Completion and Labor Market Outcomes	State-specific data	Number of courses taken	High school graduation

Author and Year	Title	Data source	Measures of exposure	Outcome
DeLuca, Plank, and Estacion (2006)	Does Career and Technical Education Affect College Enrollment?	NLSY-97	Number of courses taken; ratio of CTE to non-CTE coursework	Postsecondary attainment
Dougherty (2016)	The Effect of Career and Technical Education on Human Capital Accumulation: Causal Evidence From Massachusetts	State-specific data	Attendance at a CTE school	High school graduation; other academic (HS); labor market
Dougherty, Gottfried, and Sublett (2019)	Does Increasing Career and Technical Education Coursework in High School Boost Educational Attainment and Labor Market Outcomes?	State-specific data	Concentrator status; number of courses taken	High school graduation; labor market
Gottfried and Plasman (2018)	Linking the Timing of Career and Technical Education Coursetaking With High School Dropout and College-Going Behavior	ELS-2002	Track/program completion	High school graduation; postsecondary attainment
Gottfried, Bozick, Rose, and Moore (2016)	Does Career and Technical Education Strengthen the STEM Pipeline? Comparing Students With and Without Disabilities	NLSY-97	Track/program completion	Other academic (postsecondary)
Hanushek, Schwerdt, Woessmann, and Zhang (2017)	General Education, Vocational Education, and Labor-Market Outcomes Over the Lifecycle	International	Number of courses taken	Labor market
Iannelli and Raffe (2007)	Vocational Upper-Secondary Education and the Transition From School	International	Track/program completion	Postsecondary attainment; labor market
Kelly and Price (2009)	Vocational Education: A Clean Slate for Disengaged Students?	NELS-88	Number of courses taken	Other academic (HS)
Kemple (2008)	Career Academies: Long-Term Impacts on Labor Market Outcomes, Educational Attainment, and Transitions to Adulthood	Multiple state, original collection	Attendance at a CTE school; number of courses taken	Labor market
Kreisman and Stange (2014)	Does Vocational Course-Taking Ease School-to-Work Transitions? A Dynamic Choice Model	NLSY-97	Number of courses taken	Other academic (HS); labor market

Author and Year	Title	Data source	Measures of exposure	Outcome
Malamud and Pop-Eleches (2010)	General Education Versus Vocational Training: Evidence From an Economy in Transition	International	Track/program completion; other noncourse CTE experiences	High school graduation
Mane (1999)	Trends in the Payoff to Academic and Occupation-Specific Skills: The Short and Medium Run Returns to Academic and Vocational High School Courses for Non-College-Bound Students	NLS-72; HSB-80; NELS-88	Number of courses taken	Labor market
Maxwell et al. (2017)	Youth CareerConnect: Early Implementation Findings	Multiple state, original collection	Track/program completion; other noncourse CTE experiences	Other academic (HS)
Meer (2007)	Evidence on the Returns to Secondary Vocational Education	NELS-88	Number of courses taken	Labor market
NAVE (2004)	Earning, Learning, and Choice: CTE Works for Students and Employers	NELS-88	Concentrator status	High school graduation; postsecondary attainment; labor market
Neumark and Joyce (2001)	Evaluating School-to-Work Programs Using the New NLSY	NLSY-97	Number of courses taken	High school graduation
Neumark and Rothstein (2006)	School-to-Career Programs and Transitions to Employment and Higher Education	NLSY-97	Track/program completion; other noncourse CTE experiences	Postsecondary attainment
Plank (2001)	A Question of Balance: CTE, Academic Courses, High School Persistence, and Student Achievement	NELS-88	Ratio of CTE to non-CTE coursework; other noncourse CTE experiences	High school graduation; other academic (HS)
Stern and Briggs (2001)	Does Paid Employment Help or Hinder Performance in Secondary School? Insights From US High School Students	Multiple state, original collection	Other noncourse CTE experiences	Other academic (HS)

Author and Year	Title	Data source	Measures of exposure	Outcome
Stern, Dayton, Paik, and Weisberg (1990)	Benefits and Costs of Dropout Prevention in a High School Program Combining Academic and Vocational Education: Third-Year Results From Replications of the California Peninsula Academies	State-specific data	Attendance at a CTE school; ratio of CTE to non-CTE coursework	High school graduation
Stern, Finkelstein, Urquiola, and Cagampang (1997)	What Difference Does It Make If School and Work Are Connected? Evidence on Co-operative Education in the United States	Multiple state, original collection	Number of courses taken; ratio of CTE to non-CTE coursework	Other academic (HS)
Stevens, Kurlaender, and Grosz (2019)	Career Technical Education and Labor Market Outcomes Evidence From California Community Colleges	State-specific data	Number of courses taken	Labor market

Note. HS = high school.

This emphasis on course taking is not surprising considering the data sources used in many papers' analyses. Many papers (nine of the 30 studies) took advantage of the National Educational Longitudinal Study (NELS-88), which followed a nationally representative sample of students from eighth grade through high school graduation, as well as two follow-up surveys in 1994 and 2000 (4 and 8 years after high school graduation, respectively). The NELS-88 dataset includes transcript information for much of the sample, which allowed researchers to make comparisons between students with different academic experiences as evidenced by their course-taking patterns. Similarly, other papers (five of the 30 studies) used the National Longitudinal Survey of Youth 1997 (NLSY-97), which also included high school transcript information. Of papers not taking advantage of these two nationally representative datasets, some (seven of the 30 studies) used state-specific administrative data, whereas others (four of the 30 studies) collected original data across multiple states.

The outcome measures used were relatively consistent across papers, and many included outcomes of multiple categories. The most commonly measured outcomes were labor-market related (17 of the 30 studies); almost always, this meant some measure of earnings and/or employment status. Nearly half (12 of the 30 studies) included high school graduation as an outcome measure, with a similar number (12 of the 30 studies) including other high school achievement metrics, such as attendance, grade point average, dropout, and/or academic performance as measured by standardized test scores. Lastly, a slightly smaller portion (10 of the 30 studies) included some form of postsecondary success measure, such as enrollment or completion of an associate's or baccalaureate degree.

3. Measuring CTE in Future Research

Researchers must maintain a dispassionate position when trying to offer an accurate contrast between what a student in a CTE program or school experiences relative to their potential counterfactual condition. Because the Every Student Succeeds Act and the reauthorization of the Carl D. Perkins Act require new measurement of career preparation and cataloguing of CTE course exposure, schools, districts, and states—as well as education researchers—should take a renewed interest in trying to capture the range or dimensions of experience that may occur when students are exposed to CTE in middle school, high school, and postsecondary institutions. Furthermore, as SLDS expand to include college and workforce outcomes, these distal outcomes should increasingly be considered and included in evaluations of CTE's impact.

3.1 Measuring CTE Exposure in High School

In high school, students can participate in CTE programming in multiple ways. How one considers exposure to CTE in high school, or their counterfactual condition, should be tailored to consider these elements. Many of these measures of exposure can be quantified to provide a rich description of what it means to experience CTE, or to experience a particular type of CTE, in contrast to either not experiencing CTE or participating in a qualitatively different form of CTE experience.

3.1.a. Courses or Credit Attainment

Courses are the most fine-grained unit of CTE exposure that is likely available. They determine whether students complete a CTE concentration, which itself is a measure of student engagement on which the federal Perkins' accountability system is based. Counting the total courses taken in CTE, as well as those taken within a specific

program of study,³ offers insight into the total investment of student time (as a share of total courses) that students spend in CTE, as well as the relative focus or specific substantive interest(s) of the student. For example, a student who took three year-long CTE courses in three different programs of study should likely be thought of as substantively different from another student who took three year-long courses in one program of study. In terms of total courses, they are similar, but in terms of substantive depth and exposure, they are different. Importantly, the latter student would likely be considered a concentrator in their program of study, which would be another level of measurement that can differentiate the two student experiences.

Similar attention is necessary to how courses themselves are defined. For example, the scope of technical content covered in a year-long CTE course might differ from that included in a semester- or trimester-long course. Consequently, simply counting the number of courses completed, in lieu of credits awarded, may not produce comparable measures across sites. For this reason, researchers may wish to place greater emphasis on counting the number of credits that a student completes. Given that most states have clearly defined expectations for the award of credit units, typically based on instructional time, credit attainment may offer a more valid, reliable, and consistent means of assessing CTE engagement.

States also may count different types of credits or courses when assigning CTE concentrator status. For instance, some states do not consider an introductory-level course as part of a CTE program of study or, if they include it, may not apply it toward conferring concentrator status. For this reason, researchers will need to use caution when making any cross-state comparisons.

In some instances, there are corequisite courses, which may or may not be part of a single program of study. Career academies typically require that students complete academic courses related to their pathway theme; students may be scheduled to take the same CTE and academic courses together as a cohort, and teachers may collaborate on cross-disciplinary projects or lessons. Some corequisites are required to complete a concentration or other certificate program but may not be directly topical to a specific program or pathway. For instance, all students in New York state–approved CTE programs must take a one-half unit course in career and financial management (New York State Education Department, 2018), which is thought to complement other CTE coursework and prepare students to work in a business setting. There may be other analogous courses in other CTE settings that could be important to measure as an element of a high school student’s CTE experience, which could contribute to the treatment-control contrast.

Measures of courses and course exposure could include the following. Ideally, all would be observed, to the extent the data allow, especially as a means to distinguish the many different ways that students may make use of CTE coursework regardless of their educational setting.

- **Total CTE credits or coursework.** A general measure of intensity that captures the total technical credits or courses that a student has accumulated, measured as a raw total and/or a proportion of total credits or courses accumulated (for comparability across differing credit schemes).
- **CTE participant.** A student who completes at least one course or who accumulates any credit in a CTE program or program area. Although the relative benefit to completing a single course may be minimal, it may be helpful to differentiate those who participate in CTE from those who do not.

³ A program of study describes a progressive, nonduplicative sequence of rigorous academic and technical coursework organized within a single industry cluster and pathway aligned with state or regional industry needs. Programs are intended to span the secondary and postsecondary education levels, provide for multiple entry and exit points that incorporate credentialing, and culminate in the award of an industry-recognized credential, an associate’s degree, or a bachelor’s degree. See Section 3(41) of Perkins V.

- **CTE concentrator.** Whether a student completed a threshold level of coursework within a single CTE program or program of study, as well as an indicator of which program was completed. Because concentrator definitions can vary by program and state, local definitions are necessary. Indicators of concentration could be available from state or district agencies, but researchers must pay attention to how flags are constructed. If not, the availability of course-taking data at the student level should allow for the construction of such measures.
- **Concentrator by CTE program or program of study.** An indicator of the specific program of study in which a student completed the minimum concentration requirements (or more).
- **Multiple concentrator status.** An accounting of whether a student has completed more than one concentration (and, if so, how many and in which programs). It may be that some combinations of program of study concentration may provide students with disproportionate benefits.
- **CTE program completer.** Whether a student completed all or a recognized threshold of CTE coursework within a single program area, signifying that a student has mastered all the content offered at the secondary level, as well as an indicator of which program was completed. Because indicators of completion can vary by program and state, local definitions are necessary.

3.1.b. Delivery Models

Educators deliver CTE instruction through a variety of models. In most cases, CTE is a stand-alone program in which a subset of students participates, with technical coursework offered in parallel to their academic coursework. In other settings, CTE may function as an instructional strategy, with academic and technical coursework offered as an integrated program of study.

Comprehensive High Schools

The most common exposure is through elective coursework in comprehensive high schools. In these settings, courses in CTE programs of study replace other elective courses (e.g., art, music, world language) and are interspersed with other core graduation requirements. Here, counting total courses and credits in CTE may be a sensible approach to gauging CTE exposure. However, even in comprehensive schools, the alignment of CTE coursework, whether the courses are all part of the same program of study and could lead to a CTE concentration, must be captured. Total credits is a useful measure, particularly if the credits cover a series of related content related to depth of exposure, and possibly training in particular skills that may hold value in employment, pursuit of professional certifications, preparation for aligned college programs, or some combination of the three.

Researchers may be tempted to use the proportion of total credits taken in CTE. Such a measure is potentially problematic for work that seeks to support causal inference because the total credits that a student takes is itself endogenous. For instance, if a school or state requires 20 credits to earn a diploma, some graduates will have the minimum of 20 credits only, whereas others will have more (e.g., 26). Thus, we propose that total CTE credits could be a reasonable measure of exposure, but models also should control for total overall credits taken to account for some of the endogenous differences in total courses or credits accumulated.

Technical High Schools

Schooling models that create a more immersive experience in CTE require that researchers think differently about the elements of these experiences that differentiate them from the counterfactual conditions, which often are comprehensive high schools. One relatively new model gaining increasing attention is P-TECH, offered as a partnership by K–12, community college, and industry partners. Programming is offered in a range of science, technology, engineering, and mathematics fields, including advanced manufacturing, health care, and information technology, with students engaged in high school and college coursework. Students participate in a continuum of

WBL opportunities and may graduate with a high school diploma and an associate's degree. Efforts to conduct a causal study are now underway, with researchers employing an experimental design to evaluate the cost, implementation, and impact of seven P-TECH schools in New York City.⁴

Still, full-time technical high schools are relatively rare in the United States, although much of the causal evidence of CTE impacts comes from this setting (Jacoby & Dougherty, 2016). The reason that most causal evidence comes from these settings does not necessarily imply that they are more impactful (although this is certainly possible and something important for researchers and policymakers to determine). Rather, these settings have offered the best opportunities for quasi-random access, which lends itself to causal impact evaluation.

Quasi-random admissions processes, for example, the use of lotteries when student demand for seats outstrips supply, allow for high-quality impact evaluations. However, because full-time technical high schools offer different curricular and delivery options, they may attract students with learning styles and interests that differ from those enrolling in the typical counterfactual comprehensive high school. This difference in who selects to apply to a full-time technical high school highlights the challenges in defining the treatment and treatment contrast; selection bias exists if the type of students applying for admission differ in some way, such as ability, motivation, or learning style, than those in the general population.

Area Technical Centers/Part Time

Not all comprehensive high schools can offer all CTE programs, and in most areas of the United States, specialized schools or career academies do not exist (National Center for Education Statistics, 2012). A common solution is that multiple districts share a technical center that students from multiple districts attend part time (in addition to a residentially assigned comprehensive high school). Among other potential advantages, these centers allow districts to share the cost of offering capital intensive programs or programs for which there may be fewer teachers available (e.g., if five districts each separately tried to staff the same programs).

When defining CTE exposure, capturing whether students attend a technical center as part of their experience is critical because their overall school experience likely differs from someone who takes the same program of study, and the same total number of credits, but does so in the context of their residentially assigned comprehensive school or in a whole-school model of CTE delivery. In addition to occurring in a separate building with students from multiple districts, the technical center often entails additional transportation time to and from the home district, which can impact total instructional hours or access to other courses or extracurricular experiences in high school. A binary indicator for whether a student attends a technical center, and for how long (i.e., half-day or full-day), or a count variable that describes how many years a student attends a technical center, in what programs they concentrated, and in what types of activities they participated (e.g., WBL) likely makes sense.

Career Academies

In lieu of offering CTE as a stand-alone program, some educators have shifted toward using CTE as an instructional strategy. Here, CTE is an organizing principle for delivering an integrated program of academic and technical instruction, organized within a broadly defined career theme. Career academies may exist as a school within a school or offered wall-to-wall, meaning that all students within a high school are enrolled.

The program requirements are designed to prepare students for both college and careers, not one or the other. Students may be offered options to earn dual credit or Advanced Placement credit and participate in a continuum of WBL experiences. Rather than preparing students for a specific job, instruction exposes students to a range of

⁴ See <https://ctereseachnetwork.org/research/p-tech-9-14-schools-impact-implementation-and-cost-study> for more information.

careers to broaden their understanding of work options. Approaches including Linked Learning, High Schools That Work, the California Partnership Academies, NAF,⁵ and the National Career Academy Coalition, offer combinations of CTE coursework with elements such as WBL, integrated academic coursework and projects, cohort scheduling, career exploration and planning, and dual enrollment. Accordingly, researchers need to be aware of the underlying principles on which a career academy may be organized.

3.1.c. Programmatic Components

Moving beyond measuring CTE experiences in high school primarily by course-taking behavior and delivery options will be critical in determining the potential differences in programming and the elements that may relate to subsequent student academic and workforce outcomes. Advocates for CTE highlight the many features of CTE that make it an enriching and impactful experience. Consequently, researchers will need to consider a range of programmatic embellishments that may augment the delivery of technical programming—all or a combination of which might differentiate a student's experience in a CTE program from a traditional high school experience.

Work-Based Learning

Exposure to work and the development of work-related skills is another dimension of the high school experience that often is present in CTE programs of study. It has been hypothesized to contribute to improved workforce outcomes of students. Because of measurement issues, however, no study has yet determined whether a CTE program that includes WBL has a stronger impact than one without. The continuum of approaches used to offer WBL make it especially important to measure how and in what intensity exposure occurs. In some instances, students may receive course credit for structured internship experiences offered at work sites. In these cases, WBL may be observed through the coursework measures described earlier. However, schools also may supplement any credit-bearing experiences with additional activities that should be measured by researchers seeking to understand CTE's impact. These activities include, for example, job fairs, site visits, job shadowing, and either paid or unpaid internships.

It has been theorized (though not yet rigorously evaluated) that WBL works best when it is a series of activities that are designed to complement and build on one another. For instance, it has been suggested that a model that starts with job awareness and broad exposure but then narrows to a set of more applied experiences across years in high school, perhaps culminating with some form of short-term job placement, would likely maximize the benefits of WBL. To the extent that such models may be in use, it is important for researchers to capture various dimensions of WBL as they seek to define the CTE treatment or a treatment-control contrast.

Ideally, WBL should be measured in a way that provides detailed information on the experiencer, for example, by including information on the number of hours per week worked (i.e., a continuous variable), years in which a student participated (e.g., ranging from 0 through 4 in high school), the number of experiences per year (integer values of zero and higher), successful completion of a sequence of aligned WBL experiences (binary), a series of specific experiences expressed as a binary indicator (e.g., equal to 1 if someone had an internship, 0 otherwise), or a categorical variable measure of intensity (e.g., weeks, months, years). There may, of course, be other ways of capturing WBL (including looking at actual employment while in school using unemployment insurance data), but the critical thing is that researchers employ some measure when it is present to best define the overall CTE treatment.

Another consideration is how WBL experience is assessed. For example, attendance may be a sufficient indicator for low-intensity experiences, such as whether a student participated in a school-based job fair or a presentation

⁵ NAF was formerly the National Academies Foundation. Now it is simply NAF.

by a guest speaker. However, a more structured framework may be needed to assess the quality of students' experiences for high-intensity interactions, such as a paid internship or apprenticeship. Simply because a student participated in a WBL experience does not immediately confer benefits; researchers must have some criteria for rating the relative benefit of the involvement. Several states and national organizations have published standards for high-quality WBL, which can guide researchers' choices about what to measure (Alfeld, Charner, Johnson, & Watts, 2013; Bailey & Belfield, 2017).

Professional Certification and Credentials

High school students may have the ability to earn a professional certificate, a certification, or other postsecondary credentials as part of their CTE program of study experience. Although the value of these credentials has not been empirically established, the presence and use of them is widespread and growing (Bailey & Belfield, 2017; Office of Career, Technical, and Adult Education, 2017). The availability of these certificates should be recorded at the program of study level within a school to measure the supply or opportunity to pursue them. (Presumably, students could pursue them through pathways that are not school sponsored, but the awareness and means to do so are unclear.)

In addition to a binary indicator of whether a program of study offers an associated certificate, scholars could assess the number of certificates offered and any requirements associated with their conferral. For example, some certifications, such as a food handlers' certification or some Microsoft certifications, may require students to complete a short course of less than 12 weeks, on average. Other certifications, such as a technician certified by the National Institute for Automotive Service Excellence, may require students to complete multiple year-long courses to qualify. Moreover, not all certifications have equal labor market value, with those in technical or science, technology, engineering, and mathematics fields often conferring additional value. Consequently, researchers may need to consider assigning ratings to account for differences in the quality or utility of the credentials awarded if such differences can be established using other evidence or data, using criteria that account for their relative return on investment.

Dual Credit or Concurrent enrollment

In some instances, students completing CTE coursework may be able to earn college credit that may be applied toward fulfilling high school graduation requirements and a college certificate or degree. In other cases, credits may be recognized only by the postsecondary institution. Coursework may be offered at the high school with classes taught by a high school teacher or a college instructor certified to deliver this instruction or at a college campus by postsecondary faculty. Researchers will want to document the type of postsecondary credits offered, whether the credit may be applied toward completion of a CTE program of study, and the criteria used to determine student eligibility (e.g., achieving a minimum grade).

Attention also must be paid to whether and how college credits are used. For example, some states offer statewide credit articulation at all public 2-year colleges, whereas others may limit credits to a single institution. Such point-to-point connections are typically negotiated at the local level. Moreover, not all students who are awarded credit are able to use it, often because the student is unaware they possess the credit or because the receiving college is unwilling to apply it toward meeting degree requirements. For this reason, researchers will want to determine whether the credit is officially counted and whether the student receiving it actually benefits from its award.

Career Technical Student Organizations

Advocates for CTE and CTE educators often highlight participation in career technical student organizations (CTSOs) aligned with programs of study as a significant boon to a student's CTE experience. Participation in CTSOs is hypothesized to foster camaraderie; enhance course- and work-based training; and provide opportunities for students to apply their knowledge and skills, often through interscholastic competition (locally,

regionally, and nationally). Measuring whether a student participated in a CTSO (binary), whether it is aligned with their program of study (binary), and the number of years a student participated (ordinal) may be an effective way to describe the CTSO experience and provide another mechanism to measure the depth of student engagement in CTE in high school.

The list of known national CTSOs follows. The presence (binary), count, or intensity of participation (years, or whether students also participated in competitions or won awards) for these certainly should be measured to best define CTSOs as part of a treatment-control contrast.

- Business Professionals of America
- DECA (marketing) (formerly, Distributive Education Clubs of America)
- Future Business Leaders of America–Phi Beta Lambda
- National FFA Organization (formerly, Future Farmers of America)
- Family, Career and Community Leaders of America
- HOSA Future Health Professionals (formerly Health Occupations Student Association)
- SkillsUSA
- Technology Student Association

3.2. Measuring CTE Exposure in College

Recent work has demonstrated a positive return on investment for many CTE programs in postsecondary settings, especially community colleges where they are most common (Grosz, 2020; Stevens, Kurlaender, & Grosz, 2019). Course taking, credit accumulation, and completion of certificates or degrees are the most obvious measures of CTE exposure at the postsecondary level. Other indicators may include attainment of industry certifications or participation in WBL or an apprenticeship program. As in high school, measuring the substantive focus of these investments is critical to estimating potential impact or association with later outcomes. The value of credits, bundles of credits, and degrees or certificates has been shown to be quite heterogeneous, and estimating the potential returns of these programs in college must include this element (Smith, 2016).

The postsecondary analog to a CTE concentrator is based on levels of credit accumulation. As defined for federal Perkins V performance accountability purposes, a CTE concentrator is a student who completes at least 12 credits in a single CTE program or program of study or who completes a program of less than 12 credits. As in secondary education, multiple thresholds of exposure to CTE may occur, with measures encompassing total CTE credits; ratios of technical to overall credit completions; and CTE participation, concentration, and completion. The CTE program or program of study in which credit accumulation occurs also may be important, given differing returns to different fields of study, meaning that researchers should find ways of differentiating among students enrolling in different areas.

Certificates often are classified as short (15 credits) or long (30 credits) and are distinct from associate's degrees. Binary indicators of attainment of either type of certificate, alongside more continuous measures of credit accumulation are likely sensible and accessible measures in postsecondary education. Moreover, in some instances, certificates may be designed to be stackable, meaning that students may exit and subsequently reenroll with the ability to apply their prior evidence of skill attainment toward a higher degree.

Assessing the substantive area of credit, which is possible only in state higher education datasets or nationally representative data but not in the National Student Clearinghouse, where only enrollment and degree or certificate

attainment is captured, is important for distinguishing how postsecondary CTE training is used. For instance, in some industries or job types, stand-alone credits may be sufficient for providing professional advancement or adding to desired skills sets (Bahr, 2019). Thus, what might otherwise be measured as a failure to complete a degree or certificate could be professionally optimal behavior. Such substantive decisions or hypotheses must be defined by the researcher, and measures should be defined using the available data accordingly.

4. Defining Outcome Measures

Estimating whether and how CTE participation relates to later outcomes depends on capturing not only the contrast between CTE exposure and counterfactual conditions but also outcomes that are thought to be related to those CTE skills and experiences. When defining measures, it is helpful to define both short-term (proximal) and longer term (distal) measures that are hypothesized to be related to CTE. These measures fall into categories of behavioral/professional, academic attainment, and labor market outcomes.

Many outcome measures can be identified using administrative data records. For instance, SLDS include rich data in K–12, are increasingly linked (or linkable) to state higher education records, and often connect to the National Student Clearinghouse, which houses data from more than 93% of all postsecondary institutions nationwide (Dynarski, Hemelt, & Hyman, 2015). SLDS also are commonly linked to state unemployment insurance records, which has opened up broader access to workforce outcomes, whereas most previous work that used these outcomes relied on nationally representative survey data and thus placed a natural limit on the availability of this data (Harmon & Ridley, 2014).⁶

4.1. Measures of Engagement

CTE is hypothesized to enhance student interest in and connection to the school experience. Often, this is referred to as engagement. Although direct measures of engagement often are not possible or available (or too costly to obtain, e.g., by survey), indirect measures often are available in administrative datasets. Attendance in school (operationalized as the share of enrolled days that a student attended, e.g., attendance rate or number absences from school) is one measure that often is available and now frequently included in school accountability systems and possibly is a more reliably captured metric than in the past. Measures of student discipline or suspensions often are hypothesized to be an indirect measure of engagement. However, problems of bias in how this measure is collected, or how disciplinary outcomes are meted out, may undermine the quality of this measure, particularly in racially diverse contexts where unequal discipline practices have been documented (Rocque & Paternoster, 2011).

In postsecondary education, engagement may be operationalized as enrollment in college, total credits attempted, or total credits in a particular program area. In this context, credit attempts or credit accumulation is a proxy for persistence, which may be an indirect measure of engagement. Using measures of enrollment (binary) in college, participation in developmental coursework, or total semesters enrolled (continuous) is a means of expressing whether a student is engaged in further learning and naturally precedes any other attainment outcomes. It also is a means to record a student's trajectory after leaving high school.

⁶ Unemployment insurance data can be used to access the longitudinal, total wages paid to an employee during a given quarter. They also have relatively broad coverage and are of relatively high accuracy. These records have several drawbacks, however, including a lack of data for the self-employed and those in the military and federal civilian workforce. They also do not include information on hours worked or out-of-state migrants (i.e., earnings for graduates who move out of state). Earnings data also do not include information on employees' occupations.

4.2. Measures of Learning

Although some scholars have argued that the goal of CTE is not to enhance reading or mathematics knowledge, both sets of skills are explicitly emphasized in CTE settings. For example, technical reading and writing skills in many programs of study are comparable to nonfiction literacy skill development in non-CTE settings. Similarly, mathematics lessons may be embedded or reinforced in applied lessons in CTE classrooms that could complement or supplement such exposure in non-CTE settings. Alternatively, CTE instruction could replace, crowd out, or compete with other forms of mathematics and literacy development, if it replaces total hours of instruction in those areas or distracts students from these other areas of instruction. Thus, using standardized test scores as outcomes is a reasonable means by which one might gauge the relationship between CTE participation and measures of academic learning that are common across most K–12 settings.

Readiness for work or career is the signature outcome of CTE. WBL in the CTE field of study has been a traditional practice specifically aimed at promoting work readiness. Despite much discussion of soft, noncognitive, 21st century, and socioemotional skills—such as collaboration, communication, and problem solving in the context of work—and despite the traditional belief that WBL is better suited than ordinary classrooms or shops to develop these skills, the field lacks valid, reliable, and fair measures of these skills as demonstrated through WBL experience.

4.3. Credentials/Certificates/Competencies

The presence of professional certification or competency opportunities noted previously are possible indicators of student exposure to CTE. However, it also may be that such measures are examples of shorter term outcomes. At the student level, capturing receipt of a certificate, sitting/testing for a certificate, and a count of total certificates may be useful. Ideally, knowing a student's score on the assessment used to determine the award of a certificate also would be captured. However, most certificates offered by third parties have proprietary rights to the assessments and scores. Consequently, the award of a certification may not be included in a state's SLDS, particularly if testing occurs outside of or following program completion. In particular, measuring whether a certificate is aligned with the program of study and concentration could be of particular value when trying to assess whether CTE participation in high school seemed related to subsequent outcomes. These measures could be used as short-term outcomes or measures that could mediate subsequent student outcomes. For instance, if a long-term study used student earnings as the outcome, one could test the extent to which receipt of a professional credential in high school explains the effect on earnings.

4.4. Educational Attainment

Crossing thresholds of educational attainment, such as high school graduation or degree or certificate completion in college, often are salient outcomes that themselves are considered valuable. For instance, under human capital theory, these attainment measures are thought to describe minimum competency in particular areas that correspond to valuable skills in the workforce. Under signaling theory, such measures of attainment are a means for gaining access to credentials that send signals to employers or colleges that distinguish those with the credential from those who did not attain the credential. Regardless of which theory (or perhaps another) explains why these measures are salient, employing binary indicators of those who have earned a high school diploma, a certificate in college, or a college degree allow for the study of whether CTE participation is associated with achieving these milestones.

Researchers need to be cautious, however, when relating student achievement of CTE concentrator status to high school graduation rates or academic test scores. To qualify as a CTE concentrator, a student must complete

a relatively high threshold of CTE course taking or credit accumulation. Given that most students do not achieve this status until late in their high school career (typically in 11th or 12th grade), it might be expected that these students would have relatively higher graduation rates. In many states, students must first pass a state academic examination before they may take elective coursework, meaning that those who underperform on state assessments may be shut out from taking CTE coursework.

4.5. Labor Market Outcomes

Outcomes in the labor force have long been used to make the case for how CTE may translate into later success. The emphasis of skills and competencies with known value in the workforce has made the use of these outcomes quite desirable. This, perhaps, is why employment outcomes are so common in prior research on CTE. It has always been thought that CTE should build skills that are relevant for work; thus, employment, earnings, and wages have been desired outcomes.

Most often, labor force data are available either through nationally representative longitudinal datasets (like NLSY or those from the National Center for Education Statistics noted earlier), but increasingly, SLDS are connected to unemployment insurance records, thereby allowing for the use of labor force outcome measures. Using unemployment insurance records allows researchers to see paid employment reported for tax purposes but not that of the self-employed, those with unreported work or earnings, or in federal employment.

Unemployment insurance records report earnings per quarter by employer as well as the North American Industry Classification System code for each employer. This means that hours worked and specific job titles are not observable, which obscures the ability to observe the extent to which total hours worked (labor supply) or specific job quality impact earnings or employment. It also means that using a binary measure of employment is likely biased based on the systematic undercounting of individuals who work off the books (lower skilled, on average), are employed by the federal government, or are likely to leave the state (higher skilled, on average). Thus, using total earnings or quarters with earnings is likely the best way to measure employment outcomes.

It also is possible that researchers might use the North American Industry Classification System code to assess whether someone's industry of employment aligns with the industry associated with the program of study pursued in CTE. However, the desire for such matches is complicated by overlaps between employer classification and job type. For example, someone who works in information technology in the health care industry would be coded as employed in health care, which obscures the specific job type and match with their area of training.

5. Measuring Heterogeneity and Ensuring Equity

In the past, CTE was used to track students into inequitable academic programs (Anderson, 1982; Kantor & Tyack, 1982; Oakes, 1992). Prior scholarship highlighted clear differences in the access to program quality and type by race, ethnicity, and socioeconomic status. Furthermore, there is clear evidence of highly gendered differences in program of study participation (Hamilton, Malin, & Hackmann, 2015; Leu & Arbeit, 2020). The gendered trends are not necessarily the result of the same sort of biased treatment unearthed in the CTE tracking literature, but there almost certainly are policies as well as social norms and practices that continue to reinforce these patterns. This history of differences in experience and access to CTE based on race, class, and gender make it incredibly important for studies of CTE impacts to include explicit checks on whether access and impacts are equitable across these dimensions of student identity (as well as the overlap between these dimensions of identity).

The federal Perkins V Act includes the requirement that states assess and set performance targets for different populations of students. These legislatively specified categories include gender; race/ethnicity; and special populations of students, which include individuals with disabilities, individuals from economically disadvantaged families, individuals preparing for nontraditional fields, single parents that might include single pregnant women, out of workforce individuals, English learners, homeless individuals, youth who are in or have aged out of the foster care system, and youth with a parent on active duty in the armed forces.

States and local providers within states are expected to take steps to close performance gaps—overall and among student groups—if their outcomes fall below 90% of targeted performances. Accordingly, researchers should be well versed in the measurement populations specified in the federal legislation and understand the strategies that states are using to identify and collect data on these groups.

6. Synthesis and Future Research

As policy interest in CTE has grown, an increase in scholarship and evaluation research has followed. As this scholarship grows, it will be important to broaden the measures of CTE experiences and outcomes that are included in these studies, while simultaneously being more systematic and specific in the ways we are defining measures and terms. What we proposed earlier is a blueprint or menu of options for how to expand and operationalize such measures. The potential benefits of such an expansion are hard to understate. The range of experiences that educators, policymakers, and scholars bluntly refer to as CTE almost certainly understate the richness and heterogeneity of experiences that students encounter, thereby hampering our ability to understand whether, how, and for whom CTE provides educational or workforce benefits.

Moreover, measurement in the CTE field is dynamic, with changing definitions of CTE concentrator populations and indicator selections across time. Most recently, the July 2018 reauthorization of Perkins V has led to a redefinition of CTE concentrators, dropping the threshold from students completing three or more CTE credits in a single program area under the preceding legislation (2006–2018) to those completing at least two courses in a single CTE program or program of study).⁷ Consequently, researchers will need to use caution when comparing CTE performance outcomes across time.

Federal legislation also has introduced three new secondary indicators of program quality for assessing CTE concentrators, which include the award of a recognized postsecondary credential (as defined in the Workforce Innovation and Opportunity Act), the award of postsecondary credit within the CTE program of study, and participation in WBL (Advance CTE, 2020). States are required to report on at least one of these indicators and also have the option of developing their own additional metrics (e.g., technical skill attainment). Many states are now in the early stages of indicator design and implementation, with data set to be collected during the 2020–21 academic year. These implementation efforts are occurring at the same time that educators are adapting to changes resulting from the COVID-19 pandemic, which include the need to provide distance learning and remedial instruction for students and to absorb substantial budgetary cutbacks. Consequently, researchers will wish to use caution when using data collected during the initial years of the adoption of these indicators when seeking to analyze trend data.

⁷ Under Perkins IV, states widely interpreted the concentrator definition to constitute at least three courses in a single program or program of study, which in some states might include half- or full-year courses. States continue to have broad flexibility in establishing CTE concentrator definitions under Perkins V, with some now employing a two-credit versus two-course threshold. At the time of this writing, states' final 4-year plans describing their accountability systems had yet to be submitted.

In this paper, we focused primarily on measures that could be easily quantified using what in most places is existing data. These avenues constitute the most places where we believe expansion could be more fruitful and where there is the greatest opportunity to standardize the metrics being used. Precisely because Perkins V allows states to interpret the legislative definition of CTE concentrator status, and because state educational structures and SLDS can look so different, it is important to envision and define measures that could be replicated across state lines.

Lastly, we wish to underscore that unlike traditional academics, CTE instruction may be delivered in varying contexts with differing programmatic supports. Because it is frequently offered as an elective, students who choose to enroll in and persist may introduce selection factors that may complicate causal analysis. As research continues to take advantage of both emerging and future data sources, we close by urging a particular focus on issues of heterogeneity and selection. The development of consistent metrics provides new and exciting opportunities for research across previously unlinked contexts, but continuing to attend to differences in design, implementation, selection, and access are necessary to provide a rigorous perspective on CTE.

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Appendix. Reference Citations for Exhibit 1

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