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CTE Career & Technical Education RESEARCH NETWORK

What We Know About the Impact of Career and Technical Education: A Systematic Review of the Research

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This report was updated from the original that was released March 2024. Minor corrections were made to the impact estimates presented in Table 1; the overall findings were not dramatically changed.

This report is available on the CTE Research Network website at https://cteresearchnetwork.org/resources/2024-systematic-review.

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Introduction

Career and technical education (CTE)—sometimes referred to as vocational, occupational, and workforce education—is widespread and popular with students at both the secondary and postsecondary/tertiary levels. Yet, despite decades of research on the topic, until recently little has been known about the causal effects of CTE (and all its different varieties) on student outcomes. The Office of Career, Technical, and Adult Education (OCTAE) and the Institute of Education Sciences (IES; the independent, nonpartisan research arm of the U.S. Department of Education) funded the CTE Research Network (the Network) in 2018,[1] with funds provided under the Carl D. Perkins Career and Technical Education Act of 2006 (Perkins V), to help address this lack of evidence. By building a professional community of IES-funded CTE research teams, providing training in causal methods for CTE, and producing research tools and guides, the Network has been encouraging and strengthening CTE impact studies. This synthesis of causal CTE research spanning the past 20 years complements these efforts to inform policy and practice and guide future research.

Does CTE benefit students? If so, which students does it benefit, and in which settings? These questions are at the heart of the Network's mission. When the Network launched in September 2018, considerable descriptive and correlational research existed on CTE, much of which suggested positive student outcomes. However, only a handful of CTE studies used experimental or quasi-experimental methods to show student impacts. These include the often-cited MDRC randomized controlled trial of career academy students, which found positive impacts on male students' wages (Kemple & Scott-Clayton, 2004; Page, 2012); a more recent regression discontinuity study of students in Massachusetts CTE high schools, which found positive impacts on on-time high school graduation (Dougherty et al., 2018); and a handful of studies on other CTE programs (e.g., Castellano et al., 2014; Warner et al., 2016).

The limited amount of rigorous research on CTE programs has hindered evidence-based policymaking and hampered practitioners who seek examples of effective programming. In recent years, however, several IES-funded causal CTE studies have released new findings, including those that are part of the Network (Text Box 1). It is therefore an appropriate time to review the existing impact studies and synthesize their findings. This is the first evidence review that uses What Works Clearinghouse (WWC) standards and meta-analytic techniques to examine the causal impacts of CTE on students' secondary, postsecondary, and employment outcomes. Our decision to use WWC standards to distinguish causal studies aligns with standard IES practices.

Text Box 1. Member Studies of the 2018-Funded CTE Research Network

- The Causal Impact of Attending a Career-Technical High School on Student Achievement, High School Graduation, and College Enrollment; Shaun M. Dougherty, Boston College, Principal Investigator
- Assessing the Implementation, Impact, and Variation of CTE Innovation: NYC as a Lab for Rigorous Research; James Kemple, New York University, Principal Investigator
- PTECH 9-14 Schools: An Impact, Implementation, and Cost Study; Rachel Rosen, MDRC, Principal Investigator

[1] The American Institutes for Research, Vanderbilt University, Jobs for the Future, and the Association for CTE served as the Network Lead for the original 5-year Network; in the final year, Vanderbilt was replaced by Boston College due to the co-PI's change of institution. In 2023, OCTAE and IES funded a new iteration, the CTE Research Network 2.0, with research teams scheduled to join in late 2024.

- The Evaluation of Career and College Promise; Julie Edmunds, University of North Carolina-Greensboro, Principal Investigator
- Choice and Information: The Impact of Technology-Based Career Advising Tools on High School Students' CTE Choices and Academic Performance; Rachel Rosen, MDRC, Principal Investigator
- An Evaluation of the Efficacy of Virtual Enterprises; Lindsay Daugherty, RAND Corporation, Principal Investigator

What Is CTE?

CTE encompasses a range of education and training programs focused on providing students with the academic, technical, and employability skills they need to succeed in future careers (Text Box 2). Nationally, CTE programs serve a broad range of students, from middle schoolers to adults, in both K–12 and postsecondary education settings. In 2021–22, more than 8 million secondary students and 3.4 million postsecondary students were enrolled in CTE (Perkins Collaborative Resource Network, 2022). The vast majority of high school students take at least one CTE course (National Center for Education Statistics, 2021). Among undergraduate credential-seeking college students, 38% pursue associate degrees or certificates in occupational fields of study (Zhang & Oymak, 2018).

For more than 100 years, the federal government has provided funding for CTE, originally through the Smith-Hughes National Vocational Education Act of 1917, and most recently through the 2018 Strengthening Career and Technical Education for the 21st Century Act (known as Perkins V because it is the fifth reauthorization of the 1984 Carl D. Perkins Act).[2] In fiscal year 2023, the federal allocation was $1.4 billion, with almost all states providing additional dedicated funding (Perkins Collaborative Resource Network, 2023). Funds are allocated via formula to states, which provide grants at the local level. Perkins V includes accountability and spending requirements but allows considerable flexibility in how CTE is implemented at state and local levels.

CTE programs are often categorized into 16 career clusters, with numerous specializations within each cluster.[3] Programs are delivered in a range of formats and settings but are most commonly structured into multiyear course sequences that include work-based or other applied learning; the latter may happen in workplaces, hands-on instructional settings such as laboratories, or simulated work environments in school settings. High school CTE programs increasingly offer students opportunities to earn college credits through dual enrollment programs, as well as industry-recognized credentials through national assessments. High school programs are delivered primarily as elective offerings in comprehensive high schools, in CTE centers that students may attend full time or part time, or online. Postsecondary CTE is commonly offered at community and technical colleges.

For some decades in the past, CTE—then called vocational education—had a tarnished reputation as a track for students excluded from opportunities to pursue higher skills or higher education. It is well documented that our inequitable education system has sorted students by race, ethnicity, and social class, with students of color and low-income students more often tracked into low-quality, dead-end CTE programs. As a result, CTE was stigmatized as a program for some, but not all, students (Oakes, 2005; Ainsworth & Roscigno, 2005; Hodge et al.,

[2] https://cte.ed.gov/legislation/perkins-v
[3] The National Career Clusters® Framework organizes CTE into 16 clusters that include 79 pathways. The clusters are agriculture, food, and natural resources; architecture and construction; arts, audiovisual technology, and communications; business management and administration; education and training; finance; government and public administration; health sciences; hospitality and tourism; human services; information technology; law, public safety, corrections, and security; manufacturing; marketing; science, technology, engineering, and mathematics; and transportation, distribution, and logistics. However, not all states classify CTE into these exact 16 clusters.

2020; Oakes, 1983). In recent years, however, multiple efforts have sought to improve CTE program quality (Imperatore & Hyslop, 2018). Federal legislation that supports CTE has also increasingly recognized inequities and worked to ameliorate them in several ways. Most importantly, accountability measures in Perkins V expect high school CTE students to meet the same academic standards and graduation requirements as non-CTE students, and to be similarly well prepared for postsecondary education.

In addition, CTE now comprises coherent pathways between secondary and postsecondary education and to well-paid, middle-skill jobs. Perkins-funded programs are now expected to align with state-designated high-skill, high-wage, and/or in-demand occupations, and to be responsive to local needs. Perkins V also requires states to disaggregate CTE participation and performance by student characteristics, and to use data to address gaps among student groups. Together, Perkins V's policy and programmatic changes are designed to elevate CTE into a skill-building engine for college and career success for diverse students.

These changes will take some time to be fully implemented, which means that even the most recent CTE research does not generally examine post–Perkins V programming. In addition, the field's interest in CTE impacts after high school—e.g., impacts on college enrollment and persistence, as well as employment and earnings—means that studies often have to draw on administrative data that are several years old and reflect student experiences from that time period. As a result, the CTE evidence does not capture the most recent policy and implementation shifts, nor does it capture current students' experiences. There is still much to learn from recent studies because the causal evidence base was previously so thin.

Text Box 2. Career and Technical Education, as Defined in the Strengthening Career and Technical Education for the 21st Century Act (Perkins V)

(5) CAREER AND TECHNICAL EDUCATION.—The term "career and technical education" means organized educational activities that

(A) offer a sequence of courses that—

(i) provides individuals with rigorous academic content and relevant technical knowledge and skills needed to prepare for further education and careers in current or emerging professions, which may include high-skill, high-wage, or in-demand industry sectors or occupations, which shall be, at the secondary level, aligned with the challenging State academic standards adopted by a State under section 1111(b)(1) of the Elementary and Secondary Education Act of 1965;

(ii) provides technical skill proficiency or a recognized postsecondary credential, which may include an industry-recognized credential, a certificate, or an associate degree; and

(iii) may include prerequisite courses (other than a remedial course) that meet the requirements of this subparagraph;

(B) include competency-based, work-based, or other applied learning that supports the development of academic knowledge, higher-order reasoning and problem-solving skills, work attitudes, employability skills, technical skills, and occupation-specific skills, and knowledge of all aspects of an industry, including entrepreneurship, of an individual;

(C) to the extent practicable, coordinate between secondary and postsecondary education programs through programs of study, which may include coordination through articulation agreements, early college high school programs, dual or concurrent enrollment program opportunities, or other credit transfer agreements that provide postsecondary credit or advanced standing; and

(D) may include career exploration at the high school level or as early as the middle grades (as such term is defined in section 8101 of the Elementary and Secondary Education Act of 1965).

Research Questions Driving This Review

This evidence review was designed to address the following research questions:

1. Which types of CTE programs have been the focus of studies that make causal claims?
2. What is the impact of CTE program participation on student outcomes? Specifically, does CTE have impacts on students' secondary-level outcomes, their postsecondary educational outcomes, and their employment outcomes?
3. When examining the combination of CTE program types and relevant outcomes, for which combinations are there gaps in the causal research?

The evidence review also addressed the following exploratory question:

1. Does CTE have different impacts based on program type, student gender, or student disability status?

The Network Lead assembled a team to address these questions. This team followed a six-step process to complete the review (see Text Box 3). The team initially identified 10,048 studies as potentially relevant; of these, 280 studies were deemed eligible for review. Our team of WWC-certified reviewers then applied WWC standards (Version 4.1) for causal studies to the 280 studies and judged 38 to be relevant and likely to meet those standards.[4]

Recognizing that the WWC has recently published intervention reports and practice guides on postsecondary CTE programs and practices (e.g., Cotner et al., 2021; WWC 2021a, 2021b), we focused this review on the subset of 28 studies that examined the impact of secondary-level, CTE-related programs. These 28 studies include seven studies that are likely to meet WWC standards without reservations—that is, they involved randomized controlled trials with low attrition or had strong regression discontinuity designs. The remaining 21 studies are likely to meet WWC standards with reservations.[5] A list of the 28 studies is provided in Table A-1.

[4] Even though reviewers are certified as WWC reviewers and used the *WWC Standards and Procedures Handbook, Version 4.1* as the basis for determining if studies were capable of detecting causal relationships, this review was not part of a WWC contract and did not use the WWC's online study review guide to determine if studies met standards. For this reason, the review cannot be described as a WWC review. Our team's ratings may vary from those presented in official WWC reviews.
[5] Studies that meet WWC standards with reservations are themselves extremely heterogeneous, giving equal weight to a range of studies including some regression discontinuity designs and propensity score matching studies. In the case of matching studies, there is disagreement among scholars outside the WWC about whether these methods should be included among those that support strong causal inferences.

Text Box 3. Methods Used for the CTE Research Network's Systematic Review of Evidence on CTE Programs

The four research questions were addressed through a systematic evidence review. The review was conducted using the six-step approach described here. More details can be found in the Appendix.

Step 1. Searching for relevant literature. We followed a multipronged approach to uncover all studies that examined the effects of CTE. The approach involved (a) a systematic search through research literature databases using strings of relevant keywords; (b) a scan of the websites of major research organizations, CTE-focused professional organizations, and CTE advocacy groups; and (c) the solicitation of lists of studies from experts in CTE research. Step 1 resulted in a pool of 10,048 potentially relevant studies once duplicates had been removed.

Step 2. Screening studies for relevance. Four members of the review team scanned the titles, abstracts, and full text of documents uncovered during Step 1. Project staff answered simple "yes/no/don't know" questions about each document. Sample questions included the following: *Is the document a study? Does the document examine CTE? Does the document examine relevant outcomes? Does the document describe a comparison between students who take CTE courses and students who do not?* Documents that produced a "no" response to any of the screening questions were classified as not eligible for the review. The screening process removed 9,767 ineligible documents. One additional document was removed from the pool of potential studies because the full-text version was not available.

Step 3. Distinguishing causal studies based on WWC standards. Five WWC-certified reviewers examined the remaining 280 documents to determine if the study designs, samples, attrition rates, and analytic and reporting procedures for each contrast met WWC standards for causal studies. Reviewers used *WWC Standards and Procedures Handbook, Version 4.1* for the reviews. Of the 280 relevant studies, 38 met WWC standards. The tool used to perform these reviews produced effect size estimates for each relevant outcome. We also used equations provided in the WWC handbook to calculate the standard error for each effect size.

Step 4. Distinguishing studies conducted at the secondary education level from studies conducted with postsecondary education populations. Among the 38 studies, 10 focused on CTE-related programs provided by technical or 2-year colleges for students who are no longer in high school. We removed these 10 studies because a recently published WWC practice guide provides a summary of those studies (Cotner et al., 2021). This evidence review focuses on the remaining 28 studies.

Step 5. Coding potentially important features of CTE programs, study participants, and study settings. We coded the CTE program type described in each study and the gender and disability status of the study sample. Outcome measures were grouped into primary domains which were then arranged by the stage of life at which they occur (i.e., high school domains, college-related domains, employment-related domains).

Step 6. Synthesizing effects across studies using meta-analytic procedures. To identify evidence gaps, we grouped the 28 studies by their CTE program type and outcome domains. Combinations of program type and outcome domain for which no causal studies exist were identified as evidence gaps. We also used a set of well-documented and valid meta-analytic procedures to calculate the average effects of CTE program types on the various outcomes and outcome domains, and to determine whether the effects of CTE were related to CTE types or the characteristics of study samples. Unfortunately, our team was unable to include findings from some well-publicized studies because their study reports lacked information necessary for calculation of effect sizes.

Outcome Domains

Our evidence review team recorded study effects by outcome domains defined by the WWC in the Study Review Protocol Version 1.0, aligned with the *WWC Standards Handbook, Version 4.1*.[6] Prior to meta-analysis, our team made slight changes to these domains to better align with the purpose of this review. The following are the domains of interest:

- **Student discipline in high school.** This outcome focuses on student behavior in high school. In most cases, scores are counts of disciplinary referrals (i.e., sending students to the principal's office for disruptive behavior), detentions, and suspensions. Negative results indicate a favorable outcome, so we reversed the direction of impact estimates for this domain.
- **School attendance in high school.** In most cases, this outcome represents the percentage of days for which a student was marked present at school. This domain also includes tardiness and truancy infractions. The direction of effects for the latter two measures was reversed so that positive numbers reflect better attendance.
- **Academic achievement in high school.** This domain includes outcome measures involving student grades or grade point averages, scores on standardized achievement tests (excluding college placement tests), and the accumulation of high school credits.
- **High school completion.** This domain includes attaining a high school diploma, graduating from high school, on-time graduation, and dropping out of high school. The direction for dropping out was reversed so that positive numbers reflect higher completion rates.
- **Employability skills while in high school.** This domain includes measures that assess students' acquisition of work-related skills, workplace-related maturity, and industry-recognized certificates.
- **College readiness.** This domain includes a student's completion of Advance Placement courses, their scores on college placement tests (ACT, SAT), and their college aspirations.
- **College enrollment.** This domain focuses on enrollment in any postsecondary institution.
  - Enrollment in a 2-year institution
  - Enrollment in a 4-year institution
- **Progressing in college.** This domain focuses on returning to college at the beginning of each semester or school year.
- **Postsecondary academic achievement.** Most measures in this domain involve a student's grade point average in college.
- **College degree attainment.** This domain reflects whether a student attained a postsecondary certificate, an associate's degree, or a bachelor's degree.
- **Employment.** This domain indicates whether a student attained employment of any kind, whether full time or part time.
  - Part-time employment: For this domain, we adhered to the definition used by the study authors.
  - Full-time employment: For this domain, we adhered to the definition used by the study authors.

[6] https://ies.ed.gov/ncee/wwc/Docs/ReferenceResources/WWC_Study_Review_Protocol_1_0.pdf

- **Earnings.** This domain includes any type of earnings, including hourly wage and amount earned in a week, month, quarter, or year.

We organized these outcome domains into super-domains that reflect students' stage of life: secondary outcomes, postsecondary outcomes, and employment outcomes.

Findings

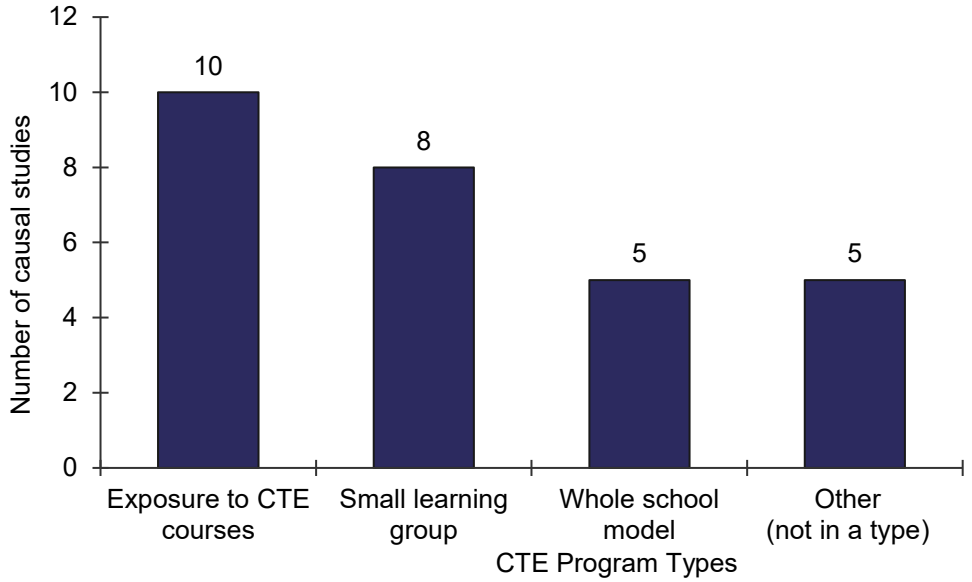
Types of CTE Programs Represented in the Studies

The first research question asks about the types of CTE programs that have been the focus of WWC-defined causal studies. The evidence review leadership team examined the types of CTE programs that were described in the 28 relevant causal studies. Programs were classified as one of the following:

- **Small learning groups.** These types of CTE programs offer career-related content and skill development to relatively small groups (or cohorts) of students who progress through multiple years of a CTE program together. Career academies are an example of this type of program (e.g., Hemelt et al., 2019; Kemple & Snipes, 2000).
- **Whole-school models.** These are entire high schools dedicated to providing all enrollees career-focused courses and experiences. These high schools generally offer students a variety of career pathways to choose from, and the pathways contain a set of aligned courses (e.g., Dougherty, 2018; Kemple et al., 2023).
- **Exposure to CTE courses.** Some studies use administrative data to compare students with CTE course credits to students without such credits and do not provide additional information on program structure or features. For example, the study of high school student outcomes in Nebraska and South Dakota (Brodersen et al., 2021) and the study of outcomes among high school graduates in Indiana and Minnesota (Lindsay et al., 2021) are population-level studies that use states' data on course completion and student outcomes to compare students who completed CTE courses to students who did not. Other studies examine students who chose CTE electives in their comprehensive high schools (e.g., Fitzgerald et al., 2016; Lee et al., 2016).
- **Other/type not specified.** This category includes all the remaining studies that look at other types of programs or interventions not represented above. For example, a study conducted by Edmunds and colleagues (2022) focused on the impacts of participating in a state-sponsored CTE dual enrollment program, while a study conducted by Stone and colleagues (2006) examined CTE courses that were infused with mathematics content.

The distribution of causal studies within these four categories is presented in Figure 1.

Figure 1. Number of Causal Studies That Have Examined Each CTE Program Type



Impacts of CTE on Student Outcomes

The meta-analytic results indicated that, in general, the impact of CTE on student outcomes was statistically significant and positive for six of the 13 outcome domains (Table 1). Across studies and types of CTE programs, student participation in CTE had statistically significant positive impacts on students' high school academic achievement, their likelihood of completing high school, their employability skills, and their college readiness. CTE had no impact on student discipline or attendance.

The results for postsecondary outcomes suggest that the causal association between CTE and college enrollment is nuanced. Compared to students who did not take CTE courses in high school, those who did were more likely to enroll in 2-year colleges (i.e., community or technical colleges). There were some negative associations with other postsecondary outcomes, such as enrollment in 4-year colleges, but they were not statistically significant and the effect sizes were close to zero. CTE had no impact on the likelihood of completing a college degree.

Students who participated in CTE in high school were more likely to be employed after high school, compared to similar classmates who did not participate in CTE in high school. However, synthesizing across the very few eligible studies that reported earnings impacts, high school CTE participation had no statistically significant impact on students' subsequent earnings.[7]

Findings for different types of CTE programs (CTE-focused small learning groups, the whole-school model, and CTE courses offered in comprehensive high schools) are provided in Table 1. We caution against overinterpreting the number of statistically significant effects for any particular program type, given that these results are based on such a small number of studies.

[7] Several influential studies that show impacts from CTE participation on future earnings are not included in these results because the study reports lacked the necessary information for calculating effect sizes.

Table 1. Effect Size Estimates for Student Outcomes, Averaged Across Studies

Outcome domain	Overall findings (all CTE program types)		CTE-focused small learning groups		Whole-school CTE model		CTE course completion	
	Number of studies	Effect size (g)	Number of studies	Effect size (g)	Number of studies	Effect size (g)	Number of studies	Effect size (g)
All student outcomes	**28**	**0.132***	**8**	**0.054**	**5**	**0.038**	**10**	**0.149***
Secondary (high school) outcomes	20	0.084*	8	0.063	5	0.069	3	0.252
Discipline	2	0.048	2	0.048				
Attendance	4	-0.048	3	-0.041	1	0.073		
Academic achievement	10	0.093*	4	0.198	3	0.044	1	0.356
High school completion	13	0.137*	5	0.058	5	0.063*	1	0.471
Employability skills	6	0.118*	3	0.160	1	0.112	1	0.108
College readiness	5	0.077*	3	0.017			1	-0.170
Postsecondary outcomes	15	0.087	4	0.023	2	-0.034	6	0.031
College enrollment	14	0.031	4	0.050	2	-0.057	5	-0.024
Enrolled in 2-year college	8	0.142*	1	0.021	1	-0.050	5	0.180*
Enrolled in 4-year college	9	-0.037	2	0.015	2	-0.052	5	-0.057
Progressing in college	5	0.327	3	-0.009			1	-0.281
Degree attainment	4	0.020	1	-0.008			3	-0.092
Employment outcomes	10	0.186*	2	-0.098	1	0.009	6	0.189
Employment	10	0.182*	2	-0.110	1	0.037	6	0.259
Part time	7	0.021	2	-0.101	1	0.037	3	0.109*
Full time	3	0.209	1	-0.022			2	0.366*
Earnings	2	0.164			1	0.180	1	0.238

Notes. g is Hedges' effect size index, which indicates the difference between the CTE group and the comparison group in standard deviation units; * indicates that the 95% confidence interval does not include 0 (i.e., that $p < .05$); empty cells indicate a research gap (either no causal studies have examined the relationship or those studies that did explore the relationship lacked the information necessary to calculate effect sizes). We caution the reader against overinterpreting the number of statistically significant effects in the columns for different program types, given that these results are based on such a small number of studies.

Source. Authors' analyses of effects from studies that were determined likely to meet WWC standards

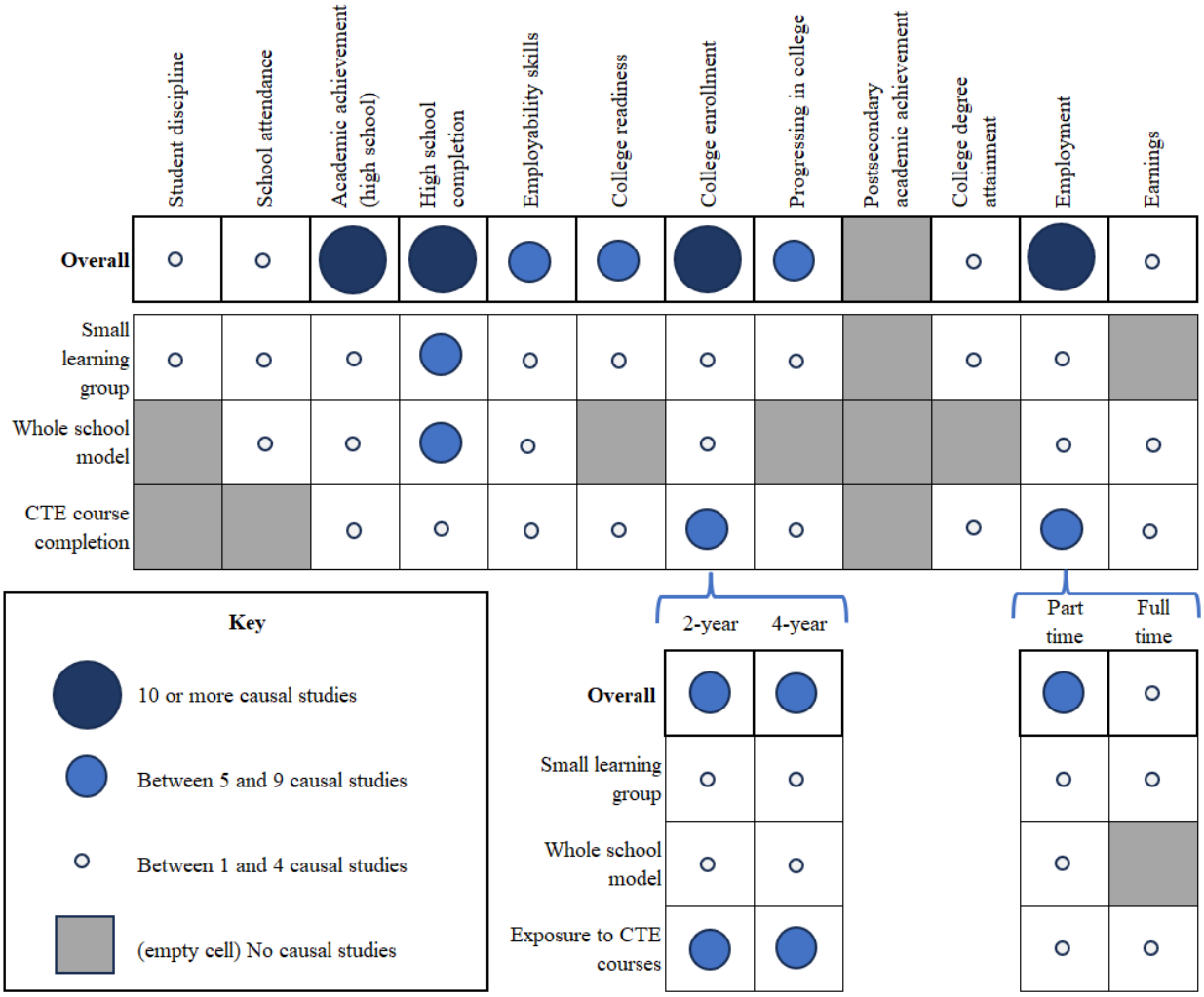
Evidence Gaps

The third research question asked about gaps in the causal research. We mapped out the terrain of CTE causal studies by listing combinations of CTE program types and outcome domains and then tabulating the number of causal studies that addressed each combination and included sufficient information to calculate effect sizes. In this way, we could identify where gaps existed in this terrain. We found that no causal studies have examined CTE impacts on student academic achievement in college. Relatively few studies (fewer than five) have examined CTE's impacts on student discipline and attendance in high school, attainment of a postsecondary degree, or later earnings. The results of the gap analysis are presented in Figure 2.

- **Studies on CTE-focused small learning groups.** The gap analysis found no causal studies that examined the impacts of CTE-focused small learning groups (e.g., career academies) on students' academic achievement in college. The impact of CTE-focused small learning groups on high school completion has been examined by between 5 and 9 studies. Impacts of CTE-focused small learning groups on all other outcomes have been examined by between one and four studies.
- **Studies of CTE high schools.** The gap analysis revealed that no studies have examined the impacts of CTE high schools on students' discipline, college readiness, progressing in college, academic achievement in college, or degree attainment.[8] The impact of assignment to a CTE high school on high school completion has been examined in five causal studies, but impacts on all other outcomes have been examined in fewer than five causal studies.
- **Studies of CTE course completion.** Among the studies on students' CTE course completion in comprehensive high schools, none have examined students' high school discipline, attendance, or their academic achievement in college. Between five and nine studies have examined the impact of CTE course completion on college enrollment and employment. Fewer than five studies have examined the impact of CTE course completion on students' high school academic achievement, their completion of high school, their college readiness, their progression in college, or the likelihood that they obtain full-time employment after high school.

[8] The final report of the P-Tech 9-14 Schools Impact, Implementation, and Cost Study was not released in time to be included in this evidence review. The study found positive impacts on associate degree attainment for the treatment group (Rosen et al., 2023).

Figure 2. Gaps in Evidence on the Effects of Career and Technical Education



Note. CTE programs classified as "other (not in a type)" are not included in the gap map.
Source. Authors' calculations are based on studies that were determined likely to meet WWC standards.

Identifying Factors That May Affect the Heterogeneity of Effects

Finally, we explored whether CTE effects varied by CTE program type, outcome domain, student gender, or student disability status. A meta-regression model was developed to test the unique contribution of each of these factors, while statistically controlling for the others. None of the regression coefficients for these factors were statistically significant. These findings suggest that, at present, there is insufficient evidence to distinguish between the impacts of different CTE types.

Conclusion

This review and synthesis used the WWC's definition of causal CTE studies to provide an important summary of the most rigorous evidence on CTE from the past 20 years to inform practitioners, policymakers, and researchers. Overall, CTE participation appears to positively impact a number of secondary-level outcomes, including high school completion; increases enrollment in 2-year colleges; and positively impacts the likelihood of employment after high school. For CTE programs generally, we found no statistically significant negative impacts. This is welcome news for the field and policymakers alike and can serve as further justification for bipartisan support for CTE.

These findings show CTE in a familiar light: high school CTE can be an effective dropout prevention program that motivates graduates to continue their education in community and technical colleges and/or prepares them for immediate employment. There is no evidence from our meta-analysis to connect CTE to enrollment in 4-year colleges, college persistence and degree attainment, or wages. Given that we did find a positive impact on college readiness, however, practitioners and policymakers may consider whether and how CTE might be better designed to prepare students for and lead to the full range of postsecondary options. In addition, state and district CTE administrators should ensure that CTE programs are offered in fields that lead to living-wage employment directly out of high school or after earning a subbaccalaureate credential.

Practitioners and policymakers would benefit from additional research targeting the outcome domains where we found no impacts, mixed impacts, or few or no studies. Hopefully, our evidence gap map can help guide researchers in designing studies to fill the identified gaps. In addition, researchers and practitioners should work together to design studies and identify measures to examine new and different outcomes, such as career development and decision making. There is national consensus that employability skills are critical to success in the workplace, highlighting a need for further studies on CTE's role in imparting these skills, which will require new, research-friendly measures.

While our review examined small learning groups and whole-school CTE delivery models, there is currently insufficient evidence to determine if any particular model produces stronger impacts than others. CTE is made available in many different formats and locations and varies across schools, districts, and states. Rigorous research is needed on common models such as regional CTE centers (which students attend for part of their school day) and on geographic regions and formats (e.g., rural areas, online) that have so far not been the subject of causal study.

Finally, we lack research on the different components of CTE—such as work-based learning—and their relative contributions to CTE impacts. A forthcoming evidence review and synthesis of work-based learning, to be conducted by the new 2023 CTE Research Network, will inform the field of any impacts and gaps in the evidence, similar to this synthesis. Career technical student organizations, which students participate in as co-curricular activities alongside their CTE programs, are thought to develop leadership and other skills, but to date there is only one study examining their effects (Alfeld et al., 2007).

While much more remains to be done, the expanding CTE evidence base can provide considerable guidance for future policy, practice, and research.

References

Ainsworth, J. W., & Roscigno, V. J. (2005). Stratification, school-work linkages and vocational education. *Social Forces, 84*(1), 257–284.

Alfeld, C., Stone, J. R., Aragon, S. R., Hansen, D. M., Zirkle, C., Connors, J., Spindler, M., Romine, R. S., & Woo, H. J. (2007). *Looking inside the black box: The value added by career and technical student organizations to students' high school experience.* National Research Center for Career and Technical Education.

Arshan, N. L., & Bosetti, K. R. (2018). *Linked learning San Bernardino: Accelerating college and career readiness in low-performing schools. An Investing in Innovation (i3) development grant evaluation.* https://www.sri.com/wp-content/uploads/2021/12/CEi3_Technical-Report_Final.pdf

Bonilla, S. (2020). The dropout effects of career pathways: Evidence from California. *Economics of Education Review, 34*.

Bozick, R., Gonzalez, G. C., Lanna, S., & Mean, M. (2019). *Preparing New York City high school students for the workforce: Evaluation of the Scholars at Work program*. Rand Corporation. https://www.rand.org/pubs/research_reports/RR2488.html

Brodersen, R. M., Gagnon, D., Liu, J., & Tedeschi, S. (2021). *The impact of career and technical education on postsecondary outcomes in Nebraska and South Dakota* (REL 2021–087). U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Central. https://eric.ed.gov/?id=ED612630

Brunner, E. J., Dougherty, S. M., & Ross, S. L. (2023). The effects of career and technical education: Evidence from the Connecticut Technical High School System. *Review of Economics and Statistics*, *105*(4), 867–882.

Additional sources:

Brunner, E., Dougherty, S., & Ross, S. L. (2022). *Industry choice within industry earning effects* (NBER Working Paper 30408). National Bureau of Economic Research.

Ecton, W. G., & Dougherty, S. M. (2021). Heterogeneity in high school career and technical education outcomes. *Educational Evaluation and Policy Analysis, 45*(1), 157–181.

Castellano, M., Sundell, K. E., & Richardson, G. B. (2017a). Achievement outcomes among high school graduates in college and career readiness programs of study. *Peabody Journal of Education, 92*(2), 254–274.

Additional sources:

Castellano, M., Richardson, G. B., Sundell, K., & Stone, J. R., III. (2017b). Preparing students for college and career in the United States: The effects of career-themed programs of study on high school performance. *Vocations and Learning, 10*, 47–70.

Castellano, M., Sundell, K., Overman, L. T., & Aliaga, O. A. (2012). Do career and technical education programs of study improve student achievement? Preliminary analyses from a rigorous longitudinal study. *International Journal of Educational Reform, 21*(2), 98–118.

Castellano, M., Sundell, K. E., Overman, L. T., Richardson, G. B., & Stone, J. R., III. (2014). *Rigorous tests of student outcomes in CTE programs of study: Final report*. National Research Center for Career and Technical Education. https://eric.ed.gov/?id=ED574506

Cotner, H., Bragg, D., Cheng, I., Costelloe, S., Freeman, B., Goold, G., Heiser, E., Lemire, S., Miller, D. G., Porowski, A., Van Noy, M., & Yadav, E. (2021). *Designing and delivering career pathways at community colleges: A practice guide for educators* (WWC 2021007). U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance. https://eric.ed.gov/?id=ED611350

Dougherty, S. M. (2018). The effect of career and technical education on human capital accumulation: Causal evidence from Massachusetts. *Education Finance and Policy, 13*(2), 119–148.

Additional source:

Dougherty, S. M., Grindal, T., & Hehir, T. (2018). The impact of career and technical education on students with disabilities. *Journal of Disability Policy Studies, 29*(2), 108–118.

Edmunds, J., Unlu, F., Phillips, B., Hutchins, B., & Mulhern, C. (2022). *CTE-focused dual enrollment: Participation and outcomes* (EdWorkingPaper 22-692). https://eric.ed.gov/?id=ED625873

Fitzgerald, R., Ottem, R., & Hufford, J. (2016). *The effect of Linked Learning certified pathways on selected student outcomes*. U.S. Department of Education, Office of Career, Technical, and Adult Education. https://eric.ed.gov/?id=ED571830

Frost, M. J. (2017). *The effects of career academies on academic achievement and college readiness* [Doctoral dissertation]. Union University. https://eric.ed.gov/?id=ED581033

Gemici, S., & Rojewski, J. W. (2010). Contributions of cooperative education in preparing at-risk students for post-high school transition. *Journal of Education for Students Placed at Risk, 15*(3), 241–258.

Hemelt, S. W., Lenard, M. A., & Paeplow, C. G. (2019). Building bridges to life after high school: Contemporary career academies and student outcomes. *Economics of Education Review, 68,* 161–178.

Additional source:

Hemelt, S. W., Lenard, M. A., & Paeplow, C. G. (2017). *Building Better Bridges to Life after High School: Experimental Evidence on Contemporary Career Academies.* National Center for Analysis of Longitudinal Data in Education Research (CALDER) Working Paper 176. https://eric.ed.gov/?id=ED572934

Hodge, E., Dougherty, S., & Burris, C. (2020). *Tracking and the future of career and technical education: How efforts to connect school and work can avoid the past mistakes of vocational education*. National Education Policy Center. http://nepc.colorado.edu/publication/cte

Hollenbeck, K., & Huang, W.-J. (2006). *Net impact and benefit-cost estimates of the workforce development system in Washington state* (Upjohn Institute Technical Report No. 06-020). Upjohn Institute. https://research.upjohn.org/cgi/viewcontent.cgi?article=1023&context=up_technicalreports

Imperatore, C., & Hyslop, A. (2018). *ACTE quality CTE program of study framework*. https://www.acteonline.org/wp-content/uploads/2019/01/HighQualityCTEFramework2018.pdf

Kemple, J. J., & Snipes, J. C. (2000). *Career academies: Impacts on students' engagement and performance in high school*. MDRC. https://eric.ed.gov/?id=ED441075

Additional sources:

Kemple, J. J. (2001). *Career academies: Impacts on students' initial transitions to post-secondary education and employment*. MDRC. https://eric.ed.gov/?id=ED463412

Kemple, J. J., & Scott-Clayton, J. (2004). *Career academies: Impacts on labor market outcomes and educational attainment*. MDRC. https://eric.ed.gov/?id=ED484616

Kemple, J. J., & Willner, C. J. (2008). *Career academies: Long-term impacts on labor market outcomes, educational attainment, and transitions to adulthood*. MDRC. https://eric.ed.gov/?id=ED631371

Kemple, J. J., Unterman, R., Dougherty, S. M., Sludden, J., & Kamin, S. J. (2023). *NYC as a laboratory for learning about career and technical education: Lessons from CTE-dedicated high schools*. The Research Alliance for New York City Schools. https://eric.ed.gov?id=ED626096

Lee, H. I., Rojewski, J. W., & Gregg, N. (2016). Causal effects of career-technical education on postsecondary work outcomes of individuals with high-incidence disabilities. *Exceptionality, 24*(2), 79–92.

Lindsay, J., Austin, M., Wan, Y., Pan, J., Pardo, M., & Yang, J. H. (2021). *Indiana and Minnesota students who focused on career and technical education in high school: Who are they, and what are their college and employment outcomes?* (REL 2021–090). U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Midwest. https://eric.ed.gov/?id=ED613044

Maxwell, N., Belotti, J., Schochet, P., Burkander, P., Whitesell, E., Dillon, E., Inanc, H. Geckeler, C., & Gonzalez, R. (2019). *Building college and career pathways for high school students: Youth CareerConnect*. Mathematica. https://eric.ed.gov/?id=ED618302

Mean, M. (2020). *Career and technical education in high school: Relationships to postsecondary trajectories and employment outcomes* [Doctoral dissertation]. University of Maryland, Baltimore County.

National Center for Education Statistics. (2021). *Percentage of public and private high school graduates who earned at least one Carnegie credit in selected career/technical education courses in high school, by selected student and school characteristics: 2019* (Table 225.25). Digest of Education Statistics.

Neild, R. C., Boccanfuso, C., & Byrnes, V. (2015). Academic impacts of career and technical schools. *Career and Technical Education Research*, *40*(1), 28–47.

Newman, L. A., Marschark, M., Shaver, D. M., & Javitz, H. (2017). Course-taking effect on postsecondary enrollment of deaf and hard of hearing students. *Exceptionality, 25*(3), 170–185.

Oakes, J. (1983). Limiting opportunity: Student race and curricular differences in secondary vocational education. *American Journal of Education, 91*(3), 328–355.

Oakes, J. (2005). *Keeping track.* Yale University Press.

Page, L. (2012). Understanding the impact of career academy attendance: An application of the principal stratification framework for causal effects accounting for partial compliance. *Evaluation Review, 36*(2), 99–132.

Perkins Collaborative Resource Network. (2022). *National enrollment profile.* U.S. Department of Education, Office of Career, Technical, and Adult Education. https://cte.ed.gov/pcrn/profile/national/enrollment/2022/participant/secondary/gender/allstudents

Perkins Collaborative Resource Network. (2023). State profiles. U.S. Department of Education, Office of Career, Technical, and Adult Education. https://cte.ed.gov/profiles/national-summary

Pustejovsky, J. E. (2023). *Meta-analysis with cluster-robust variance estimation* [Webpage]. Comprehensive R Archive Network. https://cran.r-project.org/web/packages/clubSandwich/vignettes/meta-analysis-with-CRVE.html

Pustejovsky, J. E., & Tipton, E. (2022). Meta-analysis with robust variance estimation: Expanding the range of working models. *Prevention Science*, *23*(3), 425-438.

Rosen, R., Alterman, E., Treskon, L., Parise, L., Dixon, M., & Wuest, C. (2023). P-TECH 9-14 Pathways to Success: Implementation, Impact, and Cost Findings from the New York City P-TECH 9-14 Schools Evaluation. *MDRC*. https://eric.ed.gov/?id=ED632477

Rosen, R., Byndloss, D. C., Parise, L., Alterman, E., & Dixon, M. (2020). *Bridging the school-to-work divide: Interim implementation and impact findings from New York City's P-TECH 9-14 schools*. MDRC. https://eric.ed.gov/?id=ED605308

San Miguel, M. (2013). *The effects of career technical education on student outcomes in a high-minority urban school district* [Doctoral dissertation]. California State University, Fullerton.

Stone, J. R., III, Alfeld, C., Pearson, D., Lewis, M. V., & Jensen, S. (2006). *Building academic skills in context: Testing the value of enhanced math learning in CTE.* National Research Center for Career and Technical Education. https://eric.ed.gov/?id=ED493604

Additional sources:

Stone, J. R., III, Alfeld, C., & Pearson, D. (2008). Rigor and relevance: Enhancing high school students' math skills through career and technical education. *American Educational Research Journal, 45*(3), 767–795.

Stone, J. R., III, Alfeld, C., Pearson, D., Lewis, M., & Jensen, S. (2007). *Rigor and relevance: A model of enhanced math learning in career and technical education.* National Research Center for Career and Technical Education, University of Minnesota.

Viechtbauer, W. (2010). Conducting meta-analyses in R with the metafor package. *Journal of Statistical Software, 36*(3), 1–48. https://www.jstatsoft.org/article/view/v036i03

Wagner, M. M., Newman, L. A., & Javitz, H. S. (2016). The benefits of high school career and technical education (CTE) for youth with learning disabilities. *Journal of Learning Disabilities*, *49*(6), 658–670.

Wagner, M. M., Newman, L. A., & Javitz, H. S. (2017). Vocational education course taking and post-high school employment of youth with emotional disturbances. *Career Development and Transition for Exceptional Individuals, 40*(3), 132–143.

Warner, M., Caspary, K., Arshan, N., Stites, R., Padilla, C., Patel, P., McCracken, M., Harless, E., Park, C. J., Fahimuddin, L., & Adelman, N. (2016). *Taking stock of the California Linked Learning district initiative: Seventh-year evaluation report*. SRI International.

What Works Clearinghouse (WWC). (2021a). *Project QUEST (Quality Employment through Skills Training) intervention report* (WWC 2022-001). U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation. https://eric.ed.gov/?id=ED615789

What Works Clearinghouse (WWC). (2021b). *Year Up intervention report: Postsecondary career and technical education topic report* (WWC 2022-002). U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation. https://eric.ed.gov/?id=ED615758

Witzen, B. H. (2019). *The effect of high school career and technology education on postsecondary enrollment and early career wages*. Maryland Longitudinal Data System Center.

Zhang, J., & Oymak, C. (2018). *Stats in Brief: Participants in subbaccalaureate occupational education: 2012.* U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics.

Appendix. Methods for the Systematic Evidence Review

We followed a six-step process for this systematic evidence review. First, we conducted a search for literature—journal articles, books, stand-alone book chapters, reports from government agencies and research organizations, dissertations—on career and technical education (CTE) approaches. Second, we screened the documents we found during Step 1 to ensure they were relevant to the topic of CTE. Third, we reviewed the relevant studies for quality using What Works Clearinghouse (WWC) standards. Fourth, we isolated studies that focused on CTE at the secondary level from studies of CTE programs at the postsecondary level. Fifth, we classified the studies that remained based on their approach to CTE. Finally, we summarized the results of the review by creating an evidence gap map and meta-analyzing the effects for each of the CTE approaches.

Step 1. Literature Search

We adopted a three-pronged strategy to uncover as many studies on CTE as possible. First, we entered broad strings of search terms into research literature databases. Second, we searched the websites of research organizations, relevant government agencies, and CTE professional associations. Third, we solicited lists of potential studies from researchers specializing in CTE.

Searching Research Literature Databases

Our evidence review team engaged a professional research librarian to assist with our search for relevant documents within literature databases accessed through the Ebscohost web platform. The databases included the following:

- EconLit
- Education Source
- Education Resources Information Center (ERIC)
- EdWorkingPapers
- ProQuest Dissertations and Theses Global
- ProQuest Education
- National Bureau of Economic Research (NBER) working papers
- PsychInfo

To search these databases, we developed categories of search terms that could be combined to identify empirical investigations of CTE. We developed terms reflecting career and technical evaluation (for example, “career and technical” OR CTE OR “career pathway*”); terms reflecting the population of interest (for example, “high school” OR “secondary school” OR “CTE student” OR “CTE concentrator*”); terms related to evaluation (analys* OR impact OR random* OR experiment* OR “control condition*” OR “comparison condition” OR “quasi-experiment*”); terms reflecting analytic approaches (for example, effect* OR efficac* OR gain* or growth OR increase* OR associate*); and terms reflecting outcomes of interest (for example, “academic achiev*” OR GPA OR “career read*” OR “graduat*” OR dropout OR “college enroll*” OR credential*). Our evidence review team developed the initial set of terms and the research librarian helped hone these terms to maximize the likelihood of identifying relevant documents and minimize the likelihood of identifying irrelevant documents. The comprehensive set of search terms is provided in Textbox A1. The database search yielded a list of 10,187 potentially relevant documents once duplicates had been removed.

Textbox A-1. Categories of Search Terms Used to Identify Studies of CTE

Category	Search terms
Evaluation terms	"Analys*" OR "Assess*" OR "Compar*" OR "Estimat*" OR "Evaluat*" OR "Evidence" OR "Examin*" OR "Literature review*" OR "Measur*" OR "Meta-analys*" OR "Metaanalys*" OR "Predict*" OR Systematic W1 review* OR "Varia*" OR "Impact*" OR "Random*" OR "Experiment*" OR Analyz* OR quasiexperiment* OR "propensity score matching" OR "matching" OR "matched group*" OR "difference-in-difference" OR "ABAB" OR "regression discontinuity" OR "single case design*" OR "control group*" OR "control condition*" OR "controlled" OR assign* OR "causal" OR "Post-test*" OR Treatment* OR Baseline OR "Changing criterion" OR "Single subject" OR "Alternating treatment" OR "Simultaneous treatment" OR "Reversal design" OR "Withdrawal design*" OR Posttest* OR "multiple probe" OR "multi-probe" OR "multiple baseline" OR "multi-baseline"
Population	"Middle school*" OR "High school*" OR "Secondary student*" OR "Secondary school*" OR "Career technical education student*" OR "Career and technical education student*" OR "CTE student*" OR "Vocational student*" OR "Vocational education student*" OR "School aged" OR "Youth" OR "Adolesc*" OR "Young adult*" OR "emerging adult*" OR "Grade* 6" OR "Grade* 7" OR "Grade* 8" OR "Grade* 9" OR "Grade* 10" OR "Grade* 11" OR "Grade* 12" OR "postsecondary" OR "post-secondary" OR "two-year college*" OR "2-year college*" OR "technical college*" OR "community college*" OR "associate's degree program*" OR "vocational college*" OR "career college*" OR "secondary education" OR "junior high" OR "youths" OR teen* OR "young people" OR "grade* six" OR "sixth grade*" OR "6th grade*" OR "grade* seven" OR "seventh grade*" OR "7th grade*" OR "grade* eight" OR "eighth grade*" OR "8th grade*" OR "grade* nine" OR "ninth grade*" OR "9th grade*" OR "grade* ten" OR "tenth grade*" OR "10th grade*" OR "grade* eleven" OR "eleventh grade*" OR "11th grade*" OR "grade* twelve" OR "twelfth grade*" OR "12th grade*"
Intervention terms	"career and technical" OR "CTE" OR "career-technical" OR "Vocation*" OR "occupation* education" OR "workforce education" OR "Work-based learning" OR "Area Technical Centers" OR "Career academy" OR "Career academies" OR "Technical high school*" OR "Magnet school*" OR "Magnet high school*" OR "Pathways in Technology Early College High School" OR "Career pathway*" OR "career education" OR "technical education" OR "Comprehensive High School*" OR "tech-prep" OR "internship*"
Analysis modifiers	"Affect*" OR "Benefit*" OR "Declin*" OR "Decreas*" OR "Develop*" OR "Effect*" OR "Efficac*" OR "Gain*" OR "Growth" OR "Higher" OR "Increas*" OR "Impact*" OR "Improv*" OR "Lower*" OR "Progress" OR "Reduc*" OR "Statistic*" OR "Success*" OR "influence" OR "likelihood" OR "associat*" OR "correlat*" OR "weak*" OR "streng*"

Category	Search terms
Outcome terms	"Career read*" OR "Career matur*" OR "College prep*" OR "College read*" OR "Work habit*" OR "absence*" OR "punctual*" OR "attire" OR "critical think*" OR "communication skill*" OR "problem solving" OR "teamwork" OR "team work" OR "credential*" OR "certificat*" OR "career-related skill*" OR "career skill*" OR "skill proficien*" OR "concept* know*" OR "concept* understanding" OR "ASVAB" OR "Workkeys" OR "Work keys" OR "self-efficacy" OR "academic achiev*" OR "attendance" OR "effort" OR "engage*" OR "grade point average" OR "graduat*" OR "high school completion" OR "GED" OR "drop* out*" OR dropout* OR "college enroll*" OR "postsecondary enroll*" OR "post-secondary enroll*" OR "college attendance" OR "progress* in college" OR "college persist*" OR "credit accumulat*" OR "credit attain*" OR "credit* earn*" OR "continue* enroll*" OR "course* pass*" OR "standard* test*" OR "certificate complet*" OR "attain* degree*" OR "associate's degree" OR "associates degree" OR "bachelor's degree" OR "bachelors degree" OR "attain* licens*" OR "employment" OR "employed" OR "military enlist*" OR "earning*" OR "salary" OR "wage" OR "wages" OR "pay" OR "work read*" OR "workplace read*" OR absenteeism OR "work skill*" OR "workplace skill*" OR "interpersonal skill*" OR "following directions" OR "time management" OR "work-related skill*" OR "employability skill*" OR "college success" OR "college completion" OR "degree completion" OR "degree attainment" OR "soft skills" OR "skill* acquisition" OR "letter grade*" OR "final grade*" OR "student grade*" OR "students grade*" OR "GPA" OR "Attrition" OR "immediate outcome*" OR "intermediate outcome*" OR "medium-term outcome*" OR "long-term outcome*" OR "proximal outcome*" OR "distal outcome*" OR "education* outcome*" OR "job readiness" OR "job skills" OR "job performance" OR "student outcome*" OR "income"

Notes: * is the symbol used for a wildcard. Any additional letters that follow the wildcard symbol are also included. For example, the phrase “college read*” includes college ready and college readiness.

Searching Websites of Research Organizations, Relevant Government Agencies, and CTE Professional Associations

Another component of our search strategy involved searching the websites of key organizations that might have conducted studies on CTE. In most cases, this involved accessing the section of the website labelled “research” or “resources” from the user menu and looking for documents on CTE. The search included the websites of the following organizations:

- Abt Associates
- Advance CTE
- Association for Career and Technical Education (ACTE)
- American Institutes for Research (AIR)
- Career and Technical Education Policy Exchange (CTEx)
- Career and Technical Education Research Network (CTERN)
- College and Career Alliance Support Network (CCASN)

- Community College Research Center (CCRC)
- Education Northwest
- Jobs for the Future (JFF)
- ICF International
- Mathematica
- McREL International
- MDRC
- National Bureau of Economic Research
- National Center for Education Research (NCER)
- National Center on Secondary Education and Transition (NCSET)
- National Research Center for Career and Technical Education (NRCCTE)
- U.S. Department of Education's Office of Career, Technical, and Adult Education (OCTAE)
- RAND Corporation
- SRI International
- Westat
- WestEd

The search of key organizations' websites yielded another 104 potentially relevant documents.

Soliciting Lists of Studies From CTE Researchers

The final component of our search strategy involved soliciting references for CTE-related studies from researchers participating in the CTE Research Network (the Network). We accessed the Network's previously developed bibliography of relevant studies and asked Network members to share with us any other potentially relevant studies, even those that did not produce statistically significant effects. Staff at OCTAE and IES also nominated studies for examination. This component of our search yielded an additional 28 documents.

Removing Duplicate References

The three-pronged search strategy yielded a total of 10,319 references. Of these, 271 were duplicated across the three searches and had to be removed. As a result, the pool of potentially relevant studies that entered Step 2 numbered 10,048.

Step 2. Screening Titles, Abstracts, and Full Texts for Relevance

Like most literature and evidence reviews, our three-pronged literature search identified many more references than were actually relevant. Accordingly, our team performed two screening activities to remove references that were not relevant. First, we screened study titles and abstracts to remove references that were most obviously not relevant. For each reference that survived the title/abstract screen, we obtained the full text of the document and screened it for relevance. More details about these two screening activities are described below.

Title and Abstract Screening

The project team used Abstrackr to screen the 10,048 references and their abstracts. Abstrackr is a free-access, web-based abstract screening program developed by Brown University's Center for Evidence Synthesis in Health. The program allows project directors to identify individuals who are part of the screening team and assign specific references to each member of the team for screening. Once team members log in to Abstrackr and select the project they are working on, the program presents a series of document titles and abstracts. For each document title and abstract, the screener selects one of the following: (a) a checkmark icon indicating that the abstract describes a relevant study, (b) an "X" icon indicating that the abstract describes a study that is not relevant to the review, or (c) a question mark icon ("?") indicating that the screener is unsure of whether the study is relevant based on the abstract alone. The selection for each abstract is coded as a 1, -1, or 0 for the three options, respectively.

Abstrackr is unique among screening programs in that it uses machine learning to predict the relevance of abstracts as screeners make their judgments. Abstrackr has an algorithm that identifies features of titles and abstracts that distinguish those that are relevant from those that are not relevant. The algorithm builds this prediction model and continuously tests it "in the background" as screeners make their judgments. The program continuously ranks the abstracts from most likely to be relevant to least likely to be relevant as it develops the prediction model. Once the Abstrackr prediction model converges, the program determines the probability that each of the remaining titles/abstracts is relevant. Project directors have the option of ignoring the predictions or waiting until all unscreened abstracts have a probability level low enough that the project director is confident that all remaining unscreened documents are not relevant.

For this evidence review of CTE, the project director initially assigned 4,000 abstracts among the five screeners. The project leaders decided to pause the screening activity once Abstrackr's prediction model converged and the highest probability of relevance for the remaining abstracts was 0.50. The pause point occurred after 2,800 titles and abstracts had been screened. The project director then screened an additional 50 abstracts and determined that nine would likely be relevant. Accordingly, the project director had staff screen another 305 abstracts until the highest probability of relevance was 0.40 or below. The project director then reviewed another 50 abstracts and determined that none were relevant. The remaining 6,845 study abstracts were therefore determined not to be relevant. As a result of the abstract screening process, 9,589 studies were removed from the pool of potentially relevant studies. The full-text documents for the remaining 459 potentially relevant studies progressed to the full-text screening process.

Full-Text Screening

Two research librarians retrieved all but one of the full-text study reports.[9] For each of the remaining 458 documents that passed through to full-text screening, team members responded to a set of 14 questions regarding the document's eligibility for full review. These questions asked whether the document described a study, whether the study's focus was CTE, whether the study was conducted with an eligible sample in an eligible setting, and whether it examined an eligible outcome. Studies also had to include an eligible research design. If the answer to any of the full-text screening questions was "no," the document was determined not to be relevant and was removed from the pool of studies to be included in the review. If screeners answered "unsure" to any of the screening questions, the project director determined the document's relevance. Documents for which screeners answered "yes" to all 14 questions remained in the pool of studies eligible for review using WWC

[9] One reference had no abstract and could not be screened based on the title alone. Upon further investigation, one of the project's research librarians found that the author of the report did not authorize public release of the work. This study was removed from the pool of potentially relevant studies.

standards. An additional 178 documents were removed from the pool based on the full-text screening process, leaving 280 study documents.

Step 3. Determining Whether Studies Can Detect Causal Relationships Based on WWC Standards

A group of five WWC-certified reviewers applied WWC standards to determine whether the remaining 280 studies used methods capable of detecting causal impacts of CTE.[10] The reviewers relied entirely on the contents in published studies; study authors were not queried for further information. Of the 280 studies reviewed, 44 used methods consistent with the standards for quality in *WWC's Standards and Procedures Handbook, Version 4.1*. We removed the other 236 studies from the pool of studies to be included in the review.

We then examined the 44 study documents to determine whether there was any overlap of samples within the pool of study documents. This overlap might occur if researchers reported different outcomes for each of several study documents or if researchers assessed the same students over time and reported results after each wave of data collection. Six study documents were consolidated because they shared the same samples as other studies. Although these six studies contributed effects to the meta-analysis, they were removed from the count of independent studies of CTE. The final count of CTE studies that used methods consistent with WWC standards was 38.

Step 4. Distinguishing Studies of CTE at the Secondary Level From Studies of CTE at the Postsecondary Level

The review identified 28 impact studies of secondary-level CTE programs and 10 studies of postsecondary-level CTE. The WWC recently published intervention reports and practice guides on postsecondary CTE programs and practices that included nine of the 10 studies we identified (e.g., Cotner et al., 2021; WWC, 2021a, 2021b). We therefore decided to focus this review on the subset of 28 studies that examined the impact of secondary-level, CTE-related programs and exclude the 10 postsecondary studies.

The 28 studies include seven studies that are likely to meet WWC standards without reservations—that is, they involved randomized controlled trials with low attrition. The remaining 21 studies are likely to meet WWC standards with reservations.

Steps 1–4 of the process described above are summarized in Figure A-1. A list of the final 28 studies is provided in Table A-1.

[10] Even though reviewers are certified WWC reviewers and used the *WWC Standards and Procedures Handbook, Version 4.1* as the basis for determining if studies were capable of detecting causal relationships, this review was not part of a WWC contract and did not use the WWC's online study review guide to determine if studies met standards. For this reason, the review cannot be described as a WWC review. Our team's ratings may vary from those presented in official WWC reviews.

Figure A-1. Of the 10,319 Studies Identified During the Literature Search, 28 Focused on CTE in Secondary School Settings and Used Methods Consistent With WWC Standards

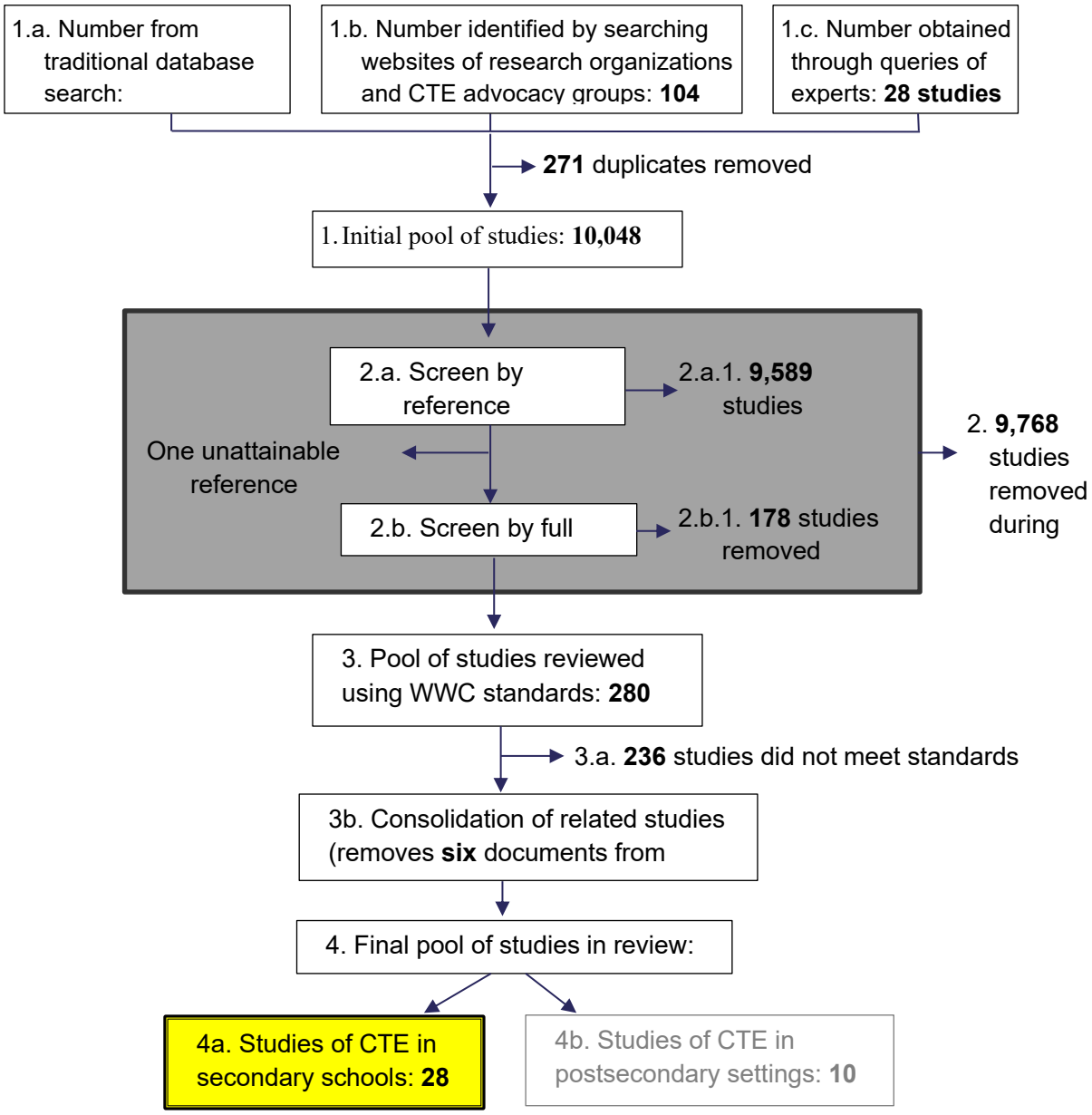


Table A-1. Studies Included in This Review

Study	CTE program	Quality rating	Outcome domains
Arshan & Bosetti (2018)	Linked Learning	Meets with reservations	Academic achievement
Bonilla (2020)[a]	Career Pathways Grants	Meets with reservations	High school completion

Study	CTE program	Quality rating	Outcome domains
Bozick et al. (2019)	Scholars at Work	Meets with reservations	Postsecondary enrollment Earnings Employment
Brodersen et al. (2021)	CTE concentration	Meets with reservations	High school completion Enrollment in 2-year institution Enrollment in 4-year institution Postsecondary degree attainment
Brunner et al. (2023)	CTE high school	Meets with reservations	High school completion Enrollment in 2-year institution Enrollment in 4-year institution Employment Earnings
Castellano et al. (2012, 2014, 2017a, 2017b)	CTE courses	Meets with reservations	Academic achievement College readiness Postsecondary persistence
Dougherty (2018)	CTE high school	Meets with reservations	Academic achievement Employability skills High school completion
Edmunds (2022)	Dual enrollment in CTE	Meets with reservations	Academic achievement High school completion Postsecondary enrollment Postsecondary persistence
Fitzgerald et al. (2016)	CTE program	Meets with reservations	Student discipline School attendance Academic achievement High school completion Postsecondary enrollment Postsecondary persistence
Frost (2017)	Career academies	Meets with reservations	College readiness
Gemici & Rojewski (2010)	Cooperative education	Meets with reservations	Employability skills Postsecondary enrollment

Study	CTE program	Quality rating	Outcome domains
Hemelt et al. (2017)	Career academies	Meets standards	High school completion College readiness Employability skills Postsecondary enrollment
Hollenbeck & Huang (2006)	CTE courses	Meets with reservations	Employment Earnings
Kemple et al. (2000, 2001, 2004, 2008)	Career academies	Meets standards	High school completion Enrollment in 2-year institution Enrollment in 4-year institution Postsecondary persistence Postsecondary degree attainment Employment Earnings
Kemple et al. (2023)	CTE high school	Meets with reservations	High school completion Enrollment in 4-year institution
Lee et al. (2016)	CTE program	Meets with reservations	Full-time employment
Lindsay et al. (2021)	CTE concentration	Meets with reservations	Enrollment in 2-year institution Enrollment in 4-year institution Postsecondary persistence Postsecondary degree attainment Employment Earnings
Maxwell et al. (2019)	Youth CareerConnect	Meets standards	School attendance Student discipline High school completion Employability skills Employment
Mean (2020)	CTE program	Meets with reservations	Enrollment in 2-year institution Enrollment in 4-year institution Employment Earnings
Neild et al. (2015)	CTE high school	Meets standards	Academic achievement Progressing in school High school completion

Study	CTE program	Quality rating	Outcome domains
Newman et al. (2017)	CTE courses	Meets with reservations	Enrollment in 2-year institution Enrollment in 4-year institution
Rosen et al. (2020)	P-TECH	Meets standards	School attendance Academic achievement High school completion
San Miguel (2013)	CTE program	Meets with reservations	School attendance Academic achievement
Stone et al. (2006)	Enhanced math in CTE	Meets standards	Academic achievement College readiness
Wagner et al. (2016)	CTE program	Meets with reservations	Employment
Wagner et al. (2017)	CTE program	Meets with reservations	Employment
Warner et al. (2016)	Linked Learning	Meets with reservations	Academic achievement High school completion Postsecondary enrollment Enrollment in 4-year institution
Witzen (2019)	CTE program completion	Meets with reservations	Employability skills Enrollment in 2-year institution Enrollment in 4-year institution Postsecondary degree attainment Earnings

[a] Effects from this study were excluded from meta-analysis because the study was performed at the school and district level.

Step 5. Coding Potentially Important Features of CTE Programs, Study Participants, and Study Settings

In order to analyze whether any features of the program, outcome, or samples might be associated with the magnitude of impact estimates, two team members coded the type of CTE program, the gender of the sample, and the sample's disability status. Coders also created a hierarchy of outcome domains that allowed meta-analysts to examine impact estimates at both broad- and fine-grained levels.

Content-area experts involved in the Network coded each of the studies into the following categories:

- **Defined small learning groups.** This category of CTE includes the following program types: career academies, Linked Learning, and Youth CareerConnect.

- **Exposure to CTE courses.** In most cases, these studies analyze administrative data of student completion of CTE courses and programs and provide limited or no information on program models or settings.
- **Whole-school model.** Whole-school models include high schools that are dedicated to providing CTE courses, where all students are expected to enroll in some sort of CTE. P-Tech is included in this program type.
- **Other.** Five studies either examined a mix of multiple CTE types or they did not fall cleanly within the other three categories.

Student gender was coded as male (for effects that were for male students only), female (for effects for female samples), or missing (for samples that had a mix of males, females, and nonbinary individuals).

Several studies focused exclusively on students with disabilities (e.g., Newman et al., 2017; Wagner et al., 2016, 2017). To explore impacts for students with disabilities, coders reexamined the studies and coded whether subgroup analyses were performed for students with disabilities versus students without disabilities. Samples that had a mix of students with and without disabilities were coded as missing.

The hierarchy of outcome domains was organized using the following scheme:

- Student outcomes
  - High school outcomes
    - Discipline
    - Attendance
    - Academic achievement
    - High school completion
    - Employability skills
    - College readiness
  - Postsecondary outcomes
    - Enrollment
      - 2-year college
      - 4-year college
    - Persistence
    - Academic achievement
    - Degree attainment
  - Employment outcomes
    - Employment
      - Part time
      - Full time
    - Earnings

Step 6. Synthesizing Effects Across Studies Using Meta-Analytic Procedures

Creating an Evidence Gap Map

One purpose of this project was to determine which combinations of CTE types and outcomes have been well studied using methods consistent with WWC standards, and which combinations have yet to be studied at all. To create the gap map, we counted the number of studies that examined each combination and then color-coded them as either white (indicating that one or more studies have examined the CTE type and outcome combination) or gray (for combinations for which quality causal studies have yet to be performed).

Meta-Analyzing the Effects for Each of the CTE Approaches

Calculation of effect sizes and standard errors. The American Institutes for Research's evidence review team used a custom-made ACCESS database to record full-text screening decisions and reviewers' judgments. Embedded in the database was a flow logic which ultimately produced a rating of whether the estimate was likely to meet WWC standards or WWC standards with reservations. The database also calculated standardized mean differences (i.e., Hedges g) for each contrast using equations listed in Appendix E of the *WWC Procedures Handbook, Version 4.1* and the handbook supplement.

The customized ACCESS database did not automatically calculate the standard errors of the estimates. Members of the review team calculated the standard errors using the other equations located in Appendix E of the handbook (and the handbook supplement).

Estimation of average effect size. We used a subgroup-correlated and hierarchical effects model to estimate the average effect sizes for each outcome domain and CTE program type (Pustejovsky & Tipton, 2021). This approach combined meta-regression analysis with a multilevel model and robust variance estimation. The multilevel model included random effects for each study and effect size to capture between-study and within-study heterogeneity in effect sizes. Each of the random effects had different variance according to the subgroup or outcome domain. We used cluster robust variance estimation to account for effect size dependency because many of the studies included in the meta-analysis produced multiple effect sizes.

The working model was as follows:

$$T_{ij,d} = \mu_d + u_{i,d} + v_{ij,d} + e_{ij,d}$$

where $T_{ij,d}$ is effect size i in study j for domain d. μ_d denotes the average effect sizes for each domain. $u_{i,d}$ is a normally distributed study-level error term with a mean of 0 and a variance of τ_d^2. $v_{ij,d}$ is a normally distributed effect-size-level error term with a mean of 0 and a variance of ω_d^2 .

$e_{ij,d}$ is a normally distributed sampling error term with a mean of 0 and a variance of $V_{ij,d}$.

We estimated the multilevel model using restricted maximum likelihood estimation, using the metafor package in R (Viechtbauer, 2010). We estimated the cluster robust variances using the clubsandwich package in R (Pustejovsky, 2023). For correlated hierarchical effects models (CHE) that did not converge, we estimated a

correlated effects model instead, which involved the assumption that the effects did not vary within the study. The model was the same as the CHE model above with the $v_{ij,d}$ term taken out.

We also used the CHE model to run the meta-regression analysis examining whether the CTE program type, outcome domain, gender, or disability status of the student sample moderated the effects of CTE. We used the following model:

$$T_{ij} = \beta_0 + \beta_1\, CTE\ \mathrm{Pr}\, ogram + \beta_2\, Domain + \beta_3\, Gender + \beta_4\, SWD + \beta_5\, MainSupplemental + u_j + v_{ij} + e_{ij}$$

Here, "CTE Program" indicates the program type; "Domain" indicates the broad outcome domain; Gender indicates whether the sample was male, female, or unspecified; and "SWD" indicates whether the sample consisted of students with disabilities, students without disabilities, or unspecified disability status. "MainSupplemental" indicates whether the finding was a main finding or a supplemental finding. The random effect terms were similar to those described above for the subgroup CHE model.

Examination of heterogeneity. $\tau^2$is an absolute measure of between-study heterogeneity; it is an estimation of the variation in true effects. We estimated τ^2 using the restricted maximum likelihood estimation in metafor, as described above. We also estimated within-study heterogeneity (indicated as ω^2). To characterize the variation in effects between studies, we presented graphs of 90% prediction intervals.

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The American Institutes for Research (AIR) and its partners—the Association for Career and Technical Education (ACTE), Boston College, and JFF—serve as the CTE Research Network Lead. The Network Lead provides network administration and coordination as well as research, training, and dissemination to increase the number and quality of CTE impact evaluations and strengthen the field's research capacity.

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