



Design Principles



EVIDENCE-BASED APPROACHES TO DESIGNING EFFECTIVE CAREER AND TECHNICAL EDUCATION PROGRAMS

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The *EdResearch for Action Design Principles Series* focuses on a single program or practice that has been proven to have positive effects on student outcomes. Authors – leading experts from across the field of education research – look across many high-quality studies of similar programs to identify the components and conditions that are key to its effective implementation. The Design Principles Series helps practitioners adapt and successfully implement an evidence-based program to meet the needs of their target population.

CENTRAL QUESTION: What are the common components of effective Career and Technical Education (CTE) programs, and how can school and district leaders ensure access and outcomes?

DESIGN PRINCIPLES AT A GLANCE



PATHWAY STRUCTURE AND ACCESS

Students who complete at least three aligned courses in a CTE career cluster experience stronger outcomes than those who take stand-alone courses.



WORK-BASED LEARNING

Work-based learning (WBL) is typically a component of effective CTE models. The most impactful WBL programs are structured, skill-building, and aligned to students' interests and career goals.



PARTNERSHIPS WITH EMPLOYERS AND COLLEGES

Partnerships with employers and with colleges strengthen the alignment between CTE programs and students' college and career opportunities, which improves students' understanding of the real expectations of the field.



TEACHER EXPERTISE AND RECRUITMENT

CTE teachers with industry experience or strong subject-matter test scores (even without traditional certification) tend to be especially effective.



STUDENT EXPLORATION AND ADVISING

Providing students with the opportunity to explore multiple CTE pathways before choosing one may help reduce misplacement and boost engagement and retention.



EQUITY AND ACCESS

Practices such as multilingual outreach, personalized career advising, barrier-free scheduling, equity-focused data use, and fair admissions processes are likely to make a meaningful impact in expanding access to and success in high-quality CTE pathways, particularly for students who have been historically underrepresented.

BREAKING DOWN THE ISSUE

KEY TERMS

- **Career clusters-** Broad categories of related jobs and industries that share common skills and knowledge. High school CTE courses are organized into these clusters, like Health Science, so students can explore a field of interest.
- **Program of study-** A multi-course sequence within a career cluster that prepares students for specific careers or postsecondary pathways. For example, within the Health Science cluster, a program of study might be Nursing, Biomedical Science, or Sports Medicine.
- **CTE concentrator-** A student who has completed at least two CTE courses within the same program of study. This designation indicates sustained engagement in a specific CTE program.
- **Work-based learning (WBL)-** The U.S. Department of Education defines three key components of WBL: 1) alignment of classroom and workplace learning; 2) application of academic, technical, and employability skills in a work-based setting; and 3) support from classroom or workplace mentors.
- **Industry-recognized credentials (IRCs)-** Recognized qualifications that are typically aligned with industry standards and are designed to demonstrate to employers that students possess job-relevant skills.

What is CTE, and why does it matter now?

Career and Technical Education (CTE) is redefining what it means to be ready for life after high school. By blending academics with hands-on training, CTE lets students explore fields like health care, IT, construction, and business while they're still in high school. Instead of choosing between “college prep” and “career prep,” CTE opens both doors.

Interest in CTE has surged: today, over 98% of public school districts report offering CTE programs to high school students. Districts provide those programs in different ways, for example, through their own district's schools, regional CTE centers or consortia, partnerships with community and four-year colleges, or by sending students to neighboring districts (see Figure 1 for more detail on CTE models). This expansion reflects both rising college costs and the shifting demands of the labor market, with federal reforms like the Perkins V Act and state accountability systems elevating CTE alongside traditional academics. Families and policymakers alike see it as a flexible pathway to higher education, well-paying jobs, or both.

CTE has evolved from its roots in vocational education, which was often stigmatized and used to track marginalized students into narrow career paths. The 2006 Perkins Act reauthorization marked a shift, rebranding the field and broadening it to include high-growth areas like IT, engineering, education, and health care. Today, CTE is designed for all students and acknowledges that nearly every career will require some form of training beyond high school.

Although [85% of U.S. high school graduates](#) have taken at least one CTE course, these programs vary widely in structure and intensity. CTE can range from individual elective classes within a traditional high school to full-time career academies that shape a student's high school experience.

Figure 1: Common CTE models

Note: These categories aren't mutually exclusive. A single district may offer CTE programs in multiple locations.

Model	Structure	Key Features	Prevalence	Example Locations
Part-Time Technical Centers	Students split time between their home high school and a technical center	Centers are equipped with industry-standard tools, labs, and technologies; extended hands-on training blocks (2–3 hrs); often serve students from multiple high schools or districts; academic instruction stays at the home school	43% of districts with CTE programs use this model (2017)	Pennsylvania Area Technical Centers
CTE-Dedicated Schools	Full-time, standalone high schools with a strong emphasis on CTE	Structured multi-course CTE pathways; integrated academic + career instruction; extensive WBL; greater program coherence and intensity	12% of districts with CTE programs use this model (2017)	Connecticut Technical High School System (CTHSS)
Career Academies	Small learning communities within high schools	Students grouped into cohorts for core and CTE classes; interdisciplinary teacher teams; career-themed curriculum; embedded work-based learning (WBL)	24% of public high schools (2008)	Wake County, Akron Public Schools, Metro Nashville Public Schools, and Pasadena Unified School District.
Early College/ Dual Enrollment	Combined high school and college coursework (Grades 9–14)	Students work towards a HS diploma and college credit; career-aligned courses in high-wage fields; strong high school-college partnerships	Limited but growing	NYC P-TECH and North Carolina Career and College Promise Dual Enrollment Program
CTE Electives in Comprehensive Schools	Standalone CTE courses offered as electives in traditional schools	Students take CTE courses, usually as electives, alongside their academic coursework. Limited curriculum alignment; limited WBL and support structures; highly variable in quality and labor market relevance	83% of districts with CTE programs use this model (2017)	Most U.S. school districts with CTE

Well-designed CTE programs promote student engagement and attendance, as well as high school graduation and later employment, especially among disadvantaged student groups.

- **Increased likelihood of employment after high school and higher earnings**
 - A study from Connecticut found that male students who attended technical high schools were 10 percentage points more likely to graduate from high school and had [32% higher average quarterly earnings](#) than their peers who did not attend these schools.
 - A descriptive study in Massachusetts found that at age 25, CTE concentrators who did not go to college [earned about \\$6,000 more per year](#) than their peers who also didn't attend college and didn't concentrate in CTE.
- **Higher high school graduation rates**
 - One study found that each CTE course taken [lowered the chance of dropping out by about 1.2%](#). The biggest benefits came from taking CTE courses in 11th and 12th grade.
 - Evidence from [Massachusetts](#) and [Connecticut](#) suggests that students who attended technical high schools were about ten percentage points more likely to graduate from high school than students who did not attend.
 - Two [causal studies](#) show positive impacts of Career Academies on high school [graduation rates](#).
 - In California, districts that received grants to support CTE [observed a 23% decrease in high school dropout rates](#).
- **Increased school engagement and attendance:**
 - Causal research found that attending a technical high school [improved attendance for male students in Connecticut](#) and for all students [in Massachusetts](#).
- **Improved academic performance:**
 - [One recent study](#) found that students in Baltimore assigned to CTE-focused high schools scored higher on the SAT math test.
 - [Evidence from Connecticut](#) also showed higher state standardized test scores in high school math and ELA, particularly for males.
- **Higher rates of college enrollment and persistence for some students**
 - Students concentrating in career clusters aligned with postsecondary education, such as health science, IT, and education, [are significantly more likely to enroll in college](#) than similar non-CTE students. This suggests that these CTE pathways may [encourage college-going among students](#) who might not have enrolled otherwise.

Some CTE clusters lead more directly to workforce entry, while others support college enrollment. Students in clusters aligned with strong college pipelines (e.g., Health Science and STEM) are more likely to enroll in and complete college. Clusters with direct-to-workforce orientations (e.g., Construction) see lower college enrollment but higher immediate earnings.

- Architecture & Construction and Manufacturing clusters [raised early-career earnings](#), especially for male students.
- Women who entered male-dominated fields like construction and manufacturing earned [equal or greater within-industry earnings than men](#), suggesting high potential returns, despite lower overall industry entry rates.

- In contrast, clusters like Business, Marketing, and Hospitality yielded weaker or no gains, likely due to less specialized training or excess supply of labor.
- Across clusters, students who work in [industries aligned with their CTE training](#) often see the largest earnings benefits.

CTE participation and career cluster enrollment vary significantly by race, gender, and income. Black and Latino students are overrepresented in lower-earning clusters and underrepresented in high-wage clusters.

- [National](#) data show that white students and male students take more CTE credits than their peers who are students of color and female. [In Michigan](#), students from low-income backgrounds are also less likely to participate in CTE than their more affluent counterparts. Further evidence [from a study of four states](#) reveals that differences in participation and concentration are driven in large part by differences across schools, where students of color are less likely to have opportunities to concentrate in CTE.
- [In South Carolina](#), Black and Latino students are concentrated in lower-wage fields like hospitality but underrepresented in high-wage areas like STEM.
- Gender gaps also mirror workforce patterns: female students are more likely to enroll in Education, Health Science, and Human Services, while male students are more likely to enroll in manual trades and STEM. For example, in Illinois, [64% of STEM CTE students are male](#).

The main barriers to equitable access to high-quality CTE programs are:

- **Unequal program availability:**
 - Students have varying levels of access to CTE programs [depending on their school](#). These differences help to explain the disparities in participation across clusters by race, ethnicity, and income.
- **Lack of early exposure and opportunities for exploration:**
 - Many students lack [access to early information and career exploration opportunities](#) needed to make informed decisions about CTE programs. Most CTE programs are not designed to allow students to explore options before committing to year-long courses.
- **Barriers to high-quality work-based learning:**
 - Meaningful work-based learning requires strong employer partnerships, which are more difficult to establish and maintain in under-resourced districts.
- **Shortages of qualified CTE instructors:**
 - Hiring instructors with industry experience is challenging in high-demand fields due to certification barriers and low salaries. Administrators report having [difficulty filling positions in CTE](#) subjects 57% of the time, compared to only 39% for academic subjects.

EVIDENCE-BASED DESIGN PRINCIPLES

The strongest evidence of CTE's impact comes from CTE-dedicated models studied using causal methods. Since most students experience CTE as electives in comprehensive high schools, this section identifies key features from effective CTE-dedicated models that can be integrated into broader settings. The practices below are likely drivers of effectiveness for impactful CTE programs.



PATHWAY STRUCTURE AND ACCESS

Students who complete at least three aligned courses in a CTE program of study experience stronger outcomes than those who take stand-alone courses.

- CTE concentrators (students who complete two or more courses in the same career cluster) consistently experience stronger outcomes than students who take just one CTE course. [One study compared outcomes for CTE concentrators against two groups](#): (1) students with no CTE courses and (2) students who took only one CTE course. The study found that, across most career clusters, concentrators saw higher cumulative earnings than both non-CTE students and one-course students. For example, by year seven after high school, non-college concentrators earned over \$6,000 more annually than comparable peers who also did not attend college but did not concentrate in CTE.
- Although federal law defines concentrator status as completing just two courses in a cluster, in practice most concentrators take more, and research suggests that three or more courses are present in most successful models—even if the precise “threshold” number is not yet known.
- In Massachusetts, CTE concentrators were [more likely to finish high school, attend and complete a two-year college program](#), and earn more right after graduation compared to those who participated in CTE without concentrating.
- States can provide guidance to schools and districts about CTE pathways. [Tennessee](#), for example, has built pathways that outline four-year sequences.



WORK-BASED LEARNING

Work-based learning (WBL) is typically a component of effective CTE models. The most impactful WBL programs are structured, skill-building, and aligned to students' interests and career goals.

- Research from Massachusetts showed that participants in programs that [offered work-based learning \(WBL\) as a core component of the CTE program](#) had better attendance in 9th grade and higher graduation rates.
- Programming that includes career-themed pathways and WBL may help to promote positive student outcomes. For example, students who participated in Linked Learning in California [were more likely to graduate from high school](#) than their peers who did not participate.
- Research from Connecticut found positive effects of CTE participation on earnings and that, for male students in Construction and Manufacturing, [about one-third of the increase in earnings](#) can be explained by hands-on, industry-specific experience through WBL. In other words, this real-world exposure helps students build technical skills and networks that facilitate initial job placement and career advancement.

- Although we don't have causal evidence on the duration of WBL programs that is needed to be effective, [Connecticut Technical Education and Career System \(CTECS\)'s WBL manual](#) describes internships with a “typical duration of three to nine months” (part-time), tied to intentional learning goals, with up to 21 school hours/week and 38 hours per 9-day cycle for seniors.
- [Strong WBL programs involve meaningful tasks](#), mentoring, and clear learning objectives. They also often include partnerships with employers, who inform the needs for equipment, staffing, and program design.
- Nebraska's [reVISION](#) initiative strengthens rural CTE by requiring districts to collaborate regionally, pooling resources, staff, and industry partnerships, to expand access to high-quality programs like cybersecurity and agri-tech even in the smallest communities. For examples on how other states are designing high-quality WBL programs, [see here](#).
- For guidance around implementing successful WBL programs, see toolkits [here](#), [here](#), and [here](#).



PARTNERSHIPS WITH EMPLOYERS AND COLLEGES

Partnerships with employers and with colleges strengthen the alignment between CTE programs and students' college and career opportunities, which improves students' understanding of the real expectations of the field.

- Partnerships between high schools and colleges that offer early college credit improve student transitions and lead to higher graduation, college enrollment, and degree completion rates. For example, [NYC's P-TECH increased associate degree completion](#) by 5 percentage points, and [North Carolina's early college model boosted postsecondary outcomes across the board](#).
- When CTE programs are tightly aligned with fields that clearly require further education (like nursing, teaching, or IT), [concentrators in these fields are more likely to continue on to college](#). In contrast, when programs are aligned with fields where entry-level jobs don't require further schooling (like construction or transportation), students are more likely to go straight into the workforce. Partnerships with colleges and employers help make these pathways possible by ensuring school-based instruction and WBL align with industry needs
- Clear WBL plans define roles and expectations for students, schools, employers, and families. [Kentucky's Department of Education](#) offers helpful resources, including a sample agreement.



TEACHER EXPERTISE AND RECRUITMENT

CTE teachers with industry experience or strong subject-matter test scores (even without traditional certification) tend to be especially effective.

- In many states, CTE teachers can enter the teaching profession through alternative pathways that count previous industry experience in place of traditional teacher training. A study in Washington found that CTE teachers who enter through Business & Industry (B&I) pathways (bringing substantial real-world work experience but not necessarily a college degree) [were at least as effective, and often more effective, than traditionally certified CTE teachers](#). Students taught by B&I teachers showed better non-test outcomes, including higher attendance, fewer disciplinary incidents, stronger GPAs, and higher on-time graduation rates. These benefits were especially pronounced for students with disabilities. This suggests that industry experience may be more effective than formal academic preparation for improving real-world academic and behavioral outcomes.

- In Massachusetts, [students earned more after graduation when taught by teachers who scored well on subject-specific licensure exams](#), especially the hands-on performance test that assesses technical skills. Those with top-scoring teachers earned about \$900 more five years out. This highlights the importance of prioritizing practical experience in state investments, such as Perkins V.
- CTE teachers with industry experience in high-growth, high-wage industries, such as health sciences and IT, can be difficult to recruit and retain. To address this, leaders can create pathways into teaching for industry experts. For example, [encouraging industry professionals to take on part-time teaching roles](#) can both help fill vacancies and serve as a stepping stone into education.



STUDENT EXPLORATION AND ADVISING

Providing students with the opportunity to explore multiple CTE pathways before choosing one may help reduce misplacement and boost engagement and retention.

- In many of the CTE models with causal evidence of impacts (such as in [Massachusetts](#), [Connecticut](#), and [New York City](#)), students have the opportunity to explore their options in their 9th-grade year before selecting a CTE program.
- For example, [in Massachusetts](#), many CTE schools offer an opportunity in which 9th-grade students rotate through each of the various CTE programs within their school on a schedule. This allows students to learn about each pathway before selecting one, helping them to make more informed decisions.
- Schools can offer opportunities for students to explore CTE areas before committing, such as offering 9th graders a course that allows them to explore three to six CTE areas before selecting the area they want to pursue.



EQUITY AND ACCESS

Practices such as multilingual outreach, personalized career advising, barrier-free scheduling, equity-focused data use, and fair admissions processes are likely to make a meaningful impact in expanding access to and success in high-quality CTE pathways, particularly for students who have been historically underrepresented.

Note: These practices offer descriptive examples of how schools can broaden access to high-value pathways, but they have not been evaluated using causal methods, so they warrant further study and thoughtful implementation.

- Student and family outreach that includes [clear, accessible information about the benefits of CTE, including through multilingual materials](#), can provide underrepresented students with the knowledge and confidence to explore high-quality pathways they might not have otherwise considered. Also, providing [clear information on local workforce needs, postsecondary education requirements, and potential earnings](#) can help students make informed decisions that align with their goals and interests. [Advance CTE provides resources for effective recruitment messaging and structures](#) to ensure every learner is aware of, feels welcome, and can be successful in CTE.

- Career advising can [equip students and families with personalized information about the full range of college and career pathways](#), including CTE options. Advising has the potential to help students understand how CTE programs can lead to both immediate workforce opportunities and further education. Online tools, such as the [O*NET Interest Profiler](#), help students explore career options by answering questions about their interests, suggesting careers that align with those interests, and highlighting the skills needed to enter each field.
- Schools that [reduce structural barriers](#) are more likely to increase access to CTE programs. This may include prioritizing CTE courses in the master schedule and expanding credit recovery options, allowing students to make up core courses without missing CTE opportunities.
- Schools that [disaggregate CTE enrollment and completion data by demographics](#) and use data flags in student information systems are better equipped to identify and address equity gaps.
- In whole-school CTE models, admissions criteria (e.g., GPA, test scores) should be [reviewed and adjusted](#) if they lead to underrepresentation of students from low-income or minoritized backgrounds. Randomized lotteries can be used as an alternative to ensure broader access, especially to high-demand programs such as STEM.

MORE TO LEARN

Industry-recognized credentials (IRCs) have the potential to help students signal job readiness, build confidence, and engage more deeply in school, but their impact depends heavily on how they are selected, valued, and integrated into programs.

- Many students earn IRCs in fields that are [not strongly linked to local labor market needs](#), meaning those credentials may have limited value in helping them secure well-paying jobs.
- A recent [descriptive study found](#) that IRCs don't seem to make much difference in whether students get a job right after high school. However, IRCs do matter for earnings. For students who are employed, earning an IRC is associated with about a 9% increase in first-year annual earnings overall, with the largest gains for students who don't attend college right away (~12.6% higher earnings). Specific fields, like cosmetology, manufacturing, transportation, public safety, and health science, show the strongest wage boosts, especially for students who do not attend college or only attend part-time.
- In [Texas](#) and [Florida](#), studies found that while credentials can boost graduation rates, widely earned ones, like digital literacy, often lack employer recognition and show no clear impact on earnings or college enrollment.
- States can improve credential value by aligning offerings with labor market demand and updating approved credential lists based on employer input and wage data, an approach used in states [like Texas and Louisiana](#).
- More causal studies are needed to understand which credentials lead to sustained success in postsecondary education and the labor market.

Note: There are features of CTE-dedicated high schools that likely contribute to effectiveness, but have not been studied in isolation using causal methods. These include cohort-based structures, greater coordination between CTE and core academic teachers, student organizations and affinity groups, higher teacher credentialing standards, and targeted funding and oversight.

PRACTICES TO AVOID

Rigid tracking systems and prerequisites that steer students into CTE pathways based on early academic performance can reinforce existing inequities by limiting access to rigorous coursework and postsecondary options.

- CTE programs that are misaligned with local labor market needs risk funneling students, especially from underserved groups, into low-wage fields. In contrast, programs [aligned with local labor market needs](#) can provide all students access to in-demand, high-wage careers.
- Sorting students into career tracks based on academic performance in early or middle grades can reinforce inequities and [lock them out of more rigorous academic pathways](#). Rigid prerequisites disproportionately [exclude students from underserved backgrounds](#).
- Policies that track disadvantaged students into lower-quality and less lucrative pathways [can limit long-term opportunities for student success and perpetuate inequities](#).

Work-based learning (WBL) programs that are brief or unstructured may fail to engage students, build meaningful skills, or benefit employers.

- [Not all WBL experiences are equally meaningful](#). Programs like one-day job shadows, occasional guest speaker visits, workplace tours, or infrequent, loosely supervised internships may offer exposure to industries, but they generally lack ongoing feedback, skill-building benchmarks, alignment with classroom content, or structured mentoring..
- WBL is likely more effective when students are matched with placements that align with their interests and given meaningful tasks and mentoring.

Staffing CTE programs with teachers who lack formal training or experience in the subject area (known as teaching “out of field”) can compromise program quality and student outcomes.

- Teachers teaching “out-of-field” [are generally less effective](#) than their in-field peers, and this also [appears to be the case for CTE teachers](#). For example, assigning a general science teacher without a computer science background to lead a computer science course likely results in weaker instruction and a less engaging experience for students.
- To invest in teacher capacity, schools can support certification and professional development in CTE content areas, recruit industry professionals (even part-time), and partner with postsecondary or workforce organizations.

This EdResearch for Action brief is a collaboration among:



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